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Simplified System of Accounts for Average Municipal Water Works

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AN accounting system should give those responsible for the operation of an enterprise information concerning the financial results of that operation. Not only end results but details must be revealed and compared with earlier similar periods, so that the causes of unsatisfactory variations in the totals can be traced and corrected.

A system of accounts that is oversimplified comprises figures which represent groupings of financial results and can give little index to the make-up or changes in the component parts of any grouping. On the other hand, systems of accounting devised to meet the requirements of public utility commission accountants are apt to be too complicated and involved for use in a municipal water works plant. They generally call for the recording of more field data regarding time and material distribution and involve more intricate accounting transactions than are justified by the relatively simple procedures of municipal financing.

Accounting Experiences

About 30 years ago, when the author was placed in charge of a municipal water works system in a New England city of about 100,000 people, he soon discovered that the system of accounting in use was oversimplified. As a result, it was difficult to determine what was happening to the costs of the various operations and the expense of maintaining the different items of plant. A survey of the accounting practices in a number of municipal water systems revealed that, generally, such oversimplified methods of accounting were in vogue. One New England city, however, had an excellent system of accounts installed by specialists in that field. After a study

of that system and such other information as was readily obtainable, the author revised the accounting methods of his local water system to make them conform somewhat more closely to good accounting practice.

A dozen years later, upon assuming the direction of operations of a large group of private water companies, it became necessary to devise a system of accounts which would enable the top company to analyze the operations of its subsidiaries and would at the same time conform, with slight modifications, to the systems prescribed by the utility commissions in the several states in which the operating companies were located. This involved an adaptation of the uniform classification of accounts for water utilities as recommended in 1921, by the National Assn. of Railroad and Utility Comrs., for adoption by state utilities commissions.

Having recently become connected with a municipal water works, the author found himself confronted, once more, with an oversimplified system of accounts, one which did not provide detailed enough comparisons or reveal sufficient information so that the trends of costs could be analyzed and corrective action taken where required. In the light of his earlier experiences and his use of various forms of comparative operating statistics during the last 30 years, the author devised a system of water accounts for Scarsdale, N.Y. That system is being described here in the hope that it may be of value to other water works men confronted with problems of accounting.

Municipal vs. Private Utility Accounting Requirements

Due to the accounting activities of the staffs of the public utility commissions of a number of states and of the Federal Power Com., many refinements have been made in the last 25 years in the systems of accounts now in use by private water utilities. Because there are basic differences in the methods of financing capital improvements in a privately owned water company and in a municipally owned water system, these account classifications, as improved and published, are not applicable directly to the needs of municipalities.

The privately owned utility can have several forms of indebtedness in the hands of the public, including various types of bonds, preferred stock and common stock. It is not the general practice to retire any of these securities, although the form and base value may be converted from time to time. The municipal water works, on the other hand, generally has, issued and outstanding, only long-term bonds which are either paid off serially throughout the life of the bonds or are retired through the use of sinking funds.

The privately owned company seldom uses revenues as a source of funds for capital improvements or for the retirement of bonds or other securities which have been issued for that purpose. Municipally owned water systems, on the other hand, quite generally retire their bonds from revenues and, in numerous instances, use a pay-as-you-go policy, in varying degrees, by expending directly from water revenues certain sums for replacements, reinforcements and extensions of plant and equipment.

It will be seen, therefore, that in adapting the systems of accounts used by private water companies to municipal use, such systems can be greatly simplified by the elimination of accounts required by complicated capital structures for the handling of several

kinds of securities, amortization of premiums and assessments on stock, intercompany transactions and the various reserves used in connection with these accounts. On the other hand, there must be inserted into the proposed system of accounts a means of handling the surplus created by the redemption of bonds by special assessments against property owners and by the direct expenditure of water revenues for plant improvements. (See Accounts 262, 263, 264, 483 and 484.)

Scarsdale System

The system of accounts now used in Scarsdale is a modification, suited to local conditions, of certain published classifications of accounts. To prepare the system for general use by any average-sized municipal water system, the published definitions of accounts have been, in certain cases, reworded, definitions of accounts peculiar to municipal operation added and the schedules of selected accounts arranged in concise order.

To simplify the private utility classifications, in addition to eliminating the capital structure items previously mentioned, the recommended system employs only four instead of nine groups of account numbers as used in private utility accounting practice. This results in some sacrifice of complete separation of general accounts and detail accounts, but it is believed that the resulting schedules are easier to understand and to use than would be the case if all nine number groups were employed.

In the *Manual of Water Works Accounting* (1), an effort is made to develop and explain a single system of accounts which can be used both by private water companies and municipal plants. In addition, methods of keeping and using the various accounts, suggested forms for recording cost and other financial data and examples of their use, are set out in great detail. The portion of the *Manual* devoted to the system of accounts is limited to a relatively brief chapter in which the complicated classification of the National Assn. of Railroad and Utilities Comrs. is set forth in schedule form. As this system is used throughout the *Manual,* the valuable information and examples which it contains tend to be somewhat too complex for the average water works superintendent and his bookkeeper. It is believed that the methods of bookkeeping and accounting set out in the *Manual* can be applied in principle to the simpler system of accounts described herein, thus extending their usefulness.

As an appendix to this paper, on p. 8, is the schedule of accounts developed by the author, together with definitions of the accounts, couched, so far as possible, in language which the water works superintendent will find familiar. Although it is not possible here to discuss the system in detail, it appears unnecessary to do so in view of the fact that it is largely self-explanatory. Certain aspects which render the system easier to understand and make it particularly useful to municipalities are, however, worthy of comment.

In general it may be said that the balance sheet accounts comprise two series of numbers: the "100" series, containing the assets, and the "200" series, covering the liabilities. The income accounts are also dealt with in two series—the revenue accounts in the "300" and the expenditures and income deductions in the "400" series. There are 111 accounts in all, some of which would be used as alternates. This number can be contracted or slightly ex-

TABLE 1

Outlined Schedule of Accounts

Balance Sheet Accounts

Assets and Other Debits	
Plant and Equipment	Account No. 100
Construction Work in Progress	Account No. 120
Invested and Special Funds	Account No. 130
Current and Accrued Assets	Account No. 140
Deferred Debits	Account No. 150
Liabilities and Other Credits	
Long-Term Debt	Account No. 200
Short-Term Debt	Account No. 220
Current and Accrued Liabilities	Account No. 230
Deferred Credits	Account No. 240
Reserves	Account No. 250
Surplus	Account No. 260
Income Accounts	
Revenues	
Sales of Water	Account No. 300
Other Revenues	Account No. 320
Expenditures and Income Deductions	
Source of Supply Expenses	Account No. 400
Pumping Expenses	Account No. 410
Purification Expenses	Account No. 420
Transmission and Distribution Expenses	Account No. 430
Customers' Accounting Expenses	Account No. 440
Administrative and General Expenses	Account No. 450
Taxes	Account No. 460
Miscellaneous Unclassified Expenses	Account No. 470
Depreciation	Account No. 475
Income Deductions	Account No. 480
Balance of Income	Account No. 490

panded to meet the needs of the individual municipality. In contrast with the 243 accounts prescribed for a Class B private company (annual revenues \$100,000 to \$250,000) and 169 accounts for a Class C company (annual revenue \$40,000 to \$100,000), the simplification becomes obvious.

In an effort to minimize the number of income accounts, complete separation of operating expenses and maintenance expenses has not been preserved. In certain types of activity in a small or medium-sized water works, it is difficult, as a practical matter, to differentiate between the time employees spend on pure operation and on pure maintenance; therefore, the costs of both kinds of work, in such cases, are included in a single account. Also, the separation of operating activities from others, when they are closely intermingled, is not attempted. Examples are the accounts called: Operation and Maintenance of Pumping Equipment; Operation and Maintenance of Purification Equipment; Operation and Maintenance of General Buildings; Operation and Maintenance of Stores, Shops and Garages; Operation and Maintenance of Miscellaneous Equipment; and Operation of Mains, Services and Storage Facilities. If separation of these combined accounts is considered desirable, it can be accomplished by including a relatively few additional numbers in the system.

The greater portion of the accounts represent detailed breakdowns of more general classification headings. A bird's-eye view of this system of accounts is given in Table 1.

Analysis of System

If a comparison is made between the schedule of main account headings in Table 1 and those used by public utility commissions for private companies, it will be noted that there are some changes in wording without change of meaning, and that there is included in the income accounts one item not found in private water company accounting. This is Account 470, Miscellaneous Unclassified Expenses. This account can be charged with those expenditures often made by a municipal water

works in preserving its organization intact in the winter time, when many types of routine work are not in progress. Such expenditures include the cost of work done for other municipal departments for which no transfer charge is made, either as a matter of policy or because they are too minor to justify transfers.

An examination of the detailed accounts set forth in the appendix of this paper will also reveal certain accounts which require explanation. Two of these accounts—those covering redemption of bonds and capital outlays paid for directly from water revenues—have already been discussed. Among the accounts are some which may not be used at all, or may only be partially used, by many water systems. These include: 101, Organization; 102, Miscellaneous Intangible Plant; 131, Investments; 143, Notes Receivable; 252, Reserve for Depreciation of Plant and Equipment; 262, Special Assessments; 304, Metered Public Use, except as a memorandum; 305A, Public Fire Service to Owning Municipality; 460, Taxes; and 475, Depreciation.

The costs listed under 101, Organization, and incurred by the municipality at the time its water system was first started, were usually borne by the taxpayers. The amounts involved were not separately accounted for and can rarely be identified at a later date for the purpose of entering them on the balance sheet of the water system.

In many water works, no costs were incurred for such things as patent rights, licenses and privileges and, therefore, 102, Miscellaneous Intangible Plant, would not be required.

It is also probable that the majority of water departments do not have free cash available in sufficient amounts to make investments in government or other types of bonds practicable. These departments will not use Account 131, Investments. By the same token, it is unusual for a water works to have money to loan against notes, even to the general tax fund of the municipality, so that Account 143, Notes Receivable, will seldom be required.

It has long been assumed by many municipal water works systems that the retirement of indebtedness from the proceeds of the operations of the department is the equivalent, at least, of providing for accrued depreciation on the plant and equipment. Other systems consider it advisable to carry on the balance sheet an amount judged to represent the accrued depreciation on the plant, in order to be certain that such depreciation is adequately covered by the retiring of capital obligations and to know, as private water companies do, the remaining value of the physical property for which the municipality's funds have been expended, irrespective of the method by which the depreciation is considered to be covered.

Because the majority of municipal plants do not attempt to set up depreciation separately, Account 252, Reserve for Depreciation of Plant and Equipment, will generally not be required. It is anticipated, however, that, as time goes on, more and more water systems will keep their accounts in a form to show accrued depreciation, estimated in line with the recognized methods of accounting and the information now becoming available as a result of the work of the Association's Committee on Survival and Retirement of Water Works Facilities.

Only rarely is the cost of extensions assessed against abutting property owners under the procedure set up under the law for levying special assessments.

Usually, therefore, Account 262, Special Assessments, will not be used.

As it is quite common practice for the water department to furnish water service free to the other departments of the municipality, Account 304, Metered Public Use, will, when used at all, probably be a memorandum account, showing the amount of water service being furnished the taxpayers without charge. In fully metered systems, it is a simple matter to keep such an account; probably it will become increasingly common practice to do so.

Likewise, it is generally the custom for public fire service to be furnished to the taxpayers of the community without charge. In Canada and in many communities in the United States this is not the practice and, in increasing numbers, water systems are charging taxpayers for fire service in relation to value of property protected, rather than to spread the cost of such fire service over the amount of water used for general purposes. In the meantime, Account 305A, Public Fire Service to Owning Municipality, will be frequently unused.

It will undoubtedly be found that the cost of collecting water bills can often be eliminated from the water department accounts. In many communities, water bills are collected by the treasurer of the municipality as a part of the regular work of the financial department for which no transfer charge is made. The use of Account 442 would be limited accordingly.

Account 460, Taxes, will generally be used to enter the costs incurred when some of the supply works or transmission mains are in adjacent communities which levy taxes on them. It will rarely carry an item representing taxes paid by the water department into the general tax fund of the municipality, although occasionally such an account may be operated as a memorandum account of such taxes.

The use of income Account 475, Depreciation, will follow the use or nonuse of balance sheet Account 252, as discussed above. It is obvious that if accruing depreciation is provided for as an operating expense, there will rarely be earnings and cash sufficient to provide also for retirement of bonds and capital outlays from net income. Of course, the cash represented by the provision for depreciation, which of itself is a bookkeeping entry, is available and would normally be used for replacements, reinforcements and extensions to the water system. Therefore, when depreciation Account 475 is used, Account 265, as surplus arising from plant and equipment charged to net income, may not equal the total of capital outlays from water revenues but only that portion over and above the amount required to maintain a reserve for depreciation.

Application of System

It is the author's belief that substantially all the remaining accounts should be used in all but very small systems, unless certain classes of plant and equipment are not included in a given water system. Methods of recording costs, revenues and expenditures should be instituted, if not presently in use, so that the basic data are available to make possible the use of this or a comparable system of accounts.

When the number and identity of the accounts to be used have been determined, the system of numbering used in the schedule in the appendix can be altered as required. There is no special significance in the subdivision numbers, so that when some accounts are eliminated, the rest of the group can be moved up and renumbered consecutively. There will then be no miss-

ing numbers in the schedule for any particular water system. The reassigned numbers can be noted opposite the original numbers in the "Definition of Accounts" for ready cross-reference.

There is attached to the appendix a typical balance sheet and a typical profit and loss statement, based upon the make-up and methods of operation in the Scarsdale Water Dept. It will be noted that many accounts are not used. Quite a few of those that are missing because Scarsdale purchases purified water at wholesale, will be quite commonly used in other water systems. Certain other accounts, such as Taxes—Accrued and Redemption of Bonds—Accrued, are missing from a year-end balance sheet but would appear on quarterly balance sheets. These accruals concern amounts which are annual items and are, therefore, closed out at the end of the fiscal year.

The figures shown for Scarsdale, particularly those on the balance sheet, are only partially those of an actual period, as certain arbitrary allocations have been made to illustrate the schedule of accounts. The breakdown of the Plant and Equipment Accounts, as shown in this balance sheet, illustrates the way in which such accounts will be set up when the cash paid for a predecessor private water company and the various cash outlays made since the date of purchase are reconciled with the physical units that now constitute the plant. Likewise, the amount in the reserve for depreciation is an arbitrarily selected figure, pending studies to determine a more accurate one.

To receive the maximum benefit from profit and loss statements, there should be tabulated, on sheets with six ruled columns, the data for the following periods:

Column 1. The quarter ending, for example, September 30 of the present year.

Column 2. The quarter ending September 30 of the previous year.

Column 3. The increase or decrease in each quarterly item.

Column 4. The current year ending September 30.

Column 5. The previous year ending September 30.

Column 6. The increase or decrease in each yearly item.

The operator will then have before him the changes that have occurred in the most recent accounting period which, in accordance with general practice in water works billing, is suggested as a quarter. There will also be shown the changes that have occurred in a full year—the four quarters ending with the current one. If the changes in the quarterly figures are inconsistent with the trend shown by the changes in the twelve months' figures, a field for investigation is apparent. Such investigation obviously should include a reexamination of the changes occurring in the same items in each of the three prior quarters of the current year.

If any item has changed substantially, comparisons of the twelve months' figures on the previous few reports will show the degree to which a trend has been established. The operator can then decide whether or not such a trend is desirable or to be expected. In any event, his attention will have been directed promptly to those things which need investigation and possible correction.

Reference

1. *Manual of Water Works Accounting.* Munic. Finance Officers Assn., Chicago, & Am. Water Works Assn., New York (1938).

Schedule of Accounts

Balance Sheet Accounts

Assets and Other Debits

Acct. No.	*Account*
100	PLANT AND EQUIPMENT
101	Organization
102	Miscellaneous Intangible Plant
103	Land and Land Rights
104	Source of Supply Structures
105	Pumping Stations
106	Purification Buildings
107	Distribution Reservoirs and Standpipes
108	General Structures and Improvements
108A	Office and General Buildings
108B	Stores, Shop and Garage Buildings
109	Pumping Equipment
109A	Steam Pumping Equipment
109B	Electric Pumping Equipment
109C	Diesel Engine Pumping Equipment
109D	Gasoline Engine Pumping Equipment
109E	Other Types of Pumping Equipment
110	Purification Equipment
111	Transmission Mains and Accessories
112	Distribution Mains and Accessories
113	Services
114	Meters
115	Hydrants and Accessories
116	Office Furniture and Equipment
117	Transportation Equipment
118	Tools and Work Equipment
119	Miscellaneous Equipment
120	CONSTRUCTION WORK IN PROGRESS
	(Numbers 121 to 129 can be reused as required in combination with chronological project numbers.)
130	INVESTED AND SPECIAL FUNDS
131	Investments
132	Miscellaneous Special Funds
140	CURRENT AND ACCRUED ASSETS
141	Cash
142	Working Funds
143	Notes Receivable
144	Accounts Receivable
145	Accrued Water Revenues
146	Materials and Supplies
147	Prepayments
150	DEFERRED DEBITS
151	Preliminary Survey and Investigation Charges
152	Miscellaneous Deferred Debits

Liabilities and Other Credits

200	LONG-TERM DEBT
201–219	Various Individual Bond Issues
220	SHORT-TERM DEBT
230	CURRENT AND ACCRUED LIABILITIES
231	Accounts Payable
232	Miscellaneous Deposits
233	Taxes Accrued
234	Interest Accrued
235	Redemption of Bonds Accrued
236	Miscellaneous Current and Accrued Liabilities
240	DEFERRED CREDITS
241	Customers' Advances for Construction
242	Miscellaneous Deferred Credits
250	RESERVES
251	Reserve for Depreciation of Plant and Equipment
252	Miscellaneous Reserves
260	SURPLUS
261	Contributions in Aid of Construction
262	Special Assessments
263	Premiums on Bonds

264 Long-Term Debt Redeemed
265 Plant and Equipment Charged to Net Income
266 Balance of Earned Surplus

Income Accounts

Revenues

300 SALES OF WATER

301 Metered Sales to General Customers
301A Residential
301B Commercial
301C Industrial
302 Flat-Rate Sales to General Customers
302A Residential
302B Commercial
303 Private Fire Service
304 Metered Public Use (Optional as Memorandum)
305 Public Fire Service
305A To Owning Municipality
305B To Outside Municipalities
306 Sales to Other Public Authorities
307 Sales to Other Water Utilities
308 Miscellaneous Water Sales

320 OTHER REVENUES

321 Customers' Forfeited Discounts and Penalties
322 Special Services to Customers
323 Merchandise and Jobbing (Net)
324 Miscellaneous Revenues

Expenditures and Income Deductions

400 SOURCE OF SUPPLY EXPENSES

401 Operation of Source of Supply Plant
402 Maintenance of Source of Supply Plant
403 Water Purchased for Resale

410 PUMPING EXPENSES

411 Operation and Maintenance of Pumping Equipment
412 Power Purchased for Pumping
413 Pumping Supplies and Expenses
414 Operation and Maintenance of Pumping Stations

420 PURIFICATION EXPENSES

421 Operation and Maintenance of Purification Equipment
422 Purification Supplies and Expenses
423 Maintenance of Purification Buildings
424 Outside Analytical Services

430 TRANSMISSION AND DISTRIBUTION EXPENSES

431 Maps and Records
432 Operation of Mains, Services and Storage Facilities
433 Removing and Resetting Meters and Other Services on Customers' Premises
434 Maintenance of Reservoirs and Standpipes
435 Maintenance of Mains and Accessories
436 Maintenance of Services
437 Maintenance of Meters
438 Maintenance of Hydrants and Accessories

440 CUSTOMERS' ACCOUNTING AND COLLECTING EXPENSES

441 Meter Reading
442 Billing, Accounting and Collecting

450 ADMINISTRATIVE AND GENERAL EXPENSES

451 Salaries of General Officials
452 Other General Office Salaries
453 General Office Supplies and Expenses
454 Special Services
455 Insurance
456 Pension System and Welfare Expenses
457 Transportation Expenses
458 Miscellaneous General Expenses
459 Operation and Maintenance of General Property
459A Operation and Maintenance of Office and General Buildings
459B Operation and Maintenance of Stores, Shops and Garages
459C Operation and Maintenance of Miscellaneous Property and Equipment

460 Taxes

470 Miscellaneous Unclassified Expenses

475 Depreciation

480 Income Deductions

481 Interest on Long-Term Debt

482 Interest on Short-Term Debt

483 Redemption of Bonds

484 Capital Outlays from Water Revenues

490 Balance of Income

Definition of Accounts

Balance Sheet Accounts

Assets and Other Debits

100. Plant and Equipment

This account shall include the original cost of the plant and equipment owned and used and useful to the municipality in its water operations and is a summation of the costs of the various classes of Plant and Equipment which are covered by Accounts 101 through 119.

101. Organization

This account shall include expenditures for organizing the enterprise and putting it into readiness to render service.

102. Miscellaneous Intangible Plant

This account shall include the cost of patent rights, licenses, privileges and other intangible properties necessary or valuable in the conduct of the municipality's water operations and not specifically chargeable to any other account.

103. Land and Land Rights

This account shall include: the cost of land owned in fee by the municipality for water operations; rights, interests and privileges held by it in land owned by others, such as lease-holds, easements, rights of way, water rights (including diversion rights, flowage rights, pondage rights, submersion rights); and other like interests in land.

104–108. Structures and Improvements

These accounts shall include the cost, in place, of structures and improvements to grounds used in water operations. Included are all permanent structures for impounding, collecting and storing water and structures, buildings, stations and shelters to support, house or safeguard property or persons, including all fixtures permanently attached to and made a part of buildings which cannot be removed therefrom without cutting into the walls, ceilings or floors, or without in some way impairing the building. This account shall be subdivided as shown below. Structures used for more than one purpose shall be classified under the subdivision of this account indicative of their principal use:

104. Source of Supply Structures
105. Pumping Stations
106. Purification Buildings
107. Distribution Reservoirs and Standpipes
108. General Structures and Improvements
108A. Office and General Buildings
108B. Stores, Shop and Garage Buildings

109. Pumping Equipment

This account shall include the cost, installed, of equipment used in the production of steam or other power, principally for use in pumping water, and the pumping plant equipment driven thereby, including:

109A. Steam Pumping Equipment
109B. Electric Pumping Equipment
109C. Diesel Engine Pumping Equipment
109D. Gasoline Engine Pumping Equipment
109E. Other Types of Pumping Equipment

110. Purification Equipment

This account shall include the cost, installed, of structures (other than the superstructure of buildings), apparatus and equipment used for the purification of water.

111. Transmission Mains and Accessories

This account shall include the cost, installed, of transmission mains or canals used for conveying water from one unit of the source of supply, purification system or pumping plant to another unit therein, where the distance is material, and for conveying water from the wall of the pumping station, impounding reservoir or other source of supply to the distribution reservoirs or mains; and also meters and appurtenances on transmission lines.

A transmission main, as distinguished from a distribution main, is used for conveying water to the distribution system, reservoirs, tanks or standpipes and has generally no, or very few, customer service connections.

112. Distribution Mains and Accessories

This account shall include the cost, installed, of distribution mains used in the delivery of water from a transmission main or the wall of a pumping station, reservoir or standpipe to the customers' services; and also meters and appurtenances located on distribution mains.

A distribution main is one from which customer service connections are taken at frequent intervals.

113. Services

This account shall include the cost, installed, of service pipes and accessories in, or leading to, the customers' premises, when the municipality incurs the cost of installing the service or when it assumes full responsibility for maintenance and replacement of property paid for by customers. This includes the cost of stub services run in anticipation of future service.

Services which have been used but have become inactive should be retired from plant and equipment immediately if there is no prospect of re-use and, in any event, should be retired by the end of the second year following that during which the service became inactive unless re-used in the interim.

114. Meters

This account shall include the cost of meters and appurtenances thereto for use in measuring the quantity of water delivered to customers, whether held in reserve or actually in service. If in service the cost of installation shall be included. When a meter is permanently retired from service, the installed cost shall be credited to this account.

115. Hydrants and Accessories

This account shall include the cost, in place, of hydrants in service owned by the municipality, including connections to the main and the cost of mains and appurtenances used exclusively for fire protection.

116. Office Furniture and Equipment

This account shall include the cost, installed, of all office furniture and equipment owned by the municipality and devoted to water service, when not permanently attached to buildings. Articles of slight value or short service life acquired subsequent to the commencement of operations shall be charged to the appropriate operating expense account and not to this account.

117. Transportation Equipment

This account shall include the cost of vehicles and other transportation equipment and garage and repair equipment when such equipment is not an integral part of the housing structure.

118. Tools and Work Equipment

This account shall include the cost of tools, implements and equipment used in construction or repair work, exclusive of

equipment includible in other equipment accounts.

119. Miscellaneous Equipment

This account shall include the cost, installed, of:

a. Equipment used for the receiving, shipping, handling and storage of materials and supplies when not an integral part of the housing structure.

b. Equipment specially provided for general shops when not an integral part of the housing structure.

c. Other general equipment, including communication equipment and apparatus used in the municipality's water operations, and which is not includible in any other account.

120. Construction Work in Progress

This account shall include the expenditures on plant and equipment in process of construction or installation but not ready for service at the date of the balance sheet.

121–129. Various Construction Projects

130. Invested and Special Funds

131. Investments

This account shall include the book cost of U.S. Government or other bonds which are legal investments for surplus municipal funds.

132. Miscellaneous Special Funds

This account shall include assets held in sinking funds, depreciation funds and other special funds and special deposits held for more than one year.

140. Current and Accrued Assets

141. Cash

This account shall include the water system's current cash funds except working funds.

142. Working Funds

This account shall include cash advanced to officials, agents, employees and others as petty cash or working funds.

143. Notes Receivable

This account shall include the cost of all collectible obligations in the form of notes receivable and similar evidences (except interest coupons) of money due on demand or within one year from the date of issue, which are not includible in other accounts.

144. Accounts Receivable

This account shall include amounts due on open accounts from customers and others for utility services, including merchandising, jobbing and contract work.

145. Accrued Water Revenues

This account shall include the estimated amount accrued to the municipality for service rendered, but not billed, as of the end of any accounting period.

146. Materials and Supplies

This account shall include the cost of unissued small tools and unapplied materials and supplies (except meters). The cost shall include, when practicable, the purchase price at the point of free delivery, plus applicable taxes on purchases, freight, insurance, costs of inspection, special tests prior to acceptance, loading and unloading, transportation and other directly assignable charges.

Inward transportation charges for materials, as far as practicable, shall be included as a part of the cost of the particular material to which they relate. Cash or other discounts on materials shall be deducted, when practicable, in determining the cost of the particular material, or credited to the account to which the material is charged. Charges or discounts which are not so handled shall be charged or credited to Account 459B, Operation and Maintenance of Stores, Shops and Garages.

Materials recovered from construction, maintenance or the retirement of property, which are not intended to be reused, shall be designated as "scrap" and charged to this account at amounts which it is estimated will be realized therefrom;

if they are intended to be re-used, they shall be charged to this account at the average price at which like materials are carried, except that large individual items of equipment, such as some purification plant equipment, shall be carried at original cost.

When materials are issued for use, this account shall be credited accordingly and scrap shall be credited to this account when disposed of at the amount at which it was charged into the account.

147. Prepayments

This account shall include amounts representing prepayments of insurance, rents, taxes, interest and miscellaneous items, and shall be kept or supported in a manner to disclose the amount of each class of prepayments.

150. DEFERRED DEBITS

151. Preliminary Survey and Investigation Charges

This account shall be charged with all expenditures for preliminary surveys, plans and investigations made for the purpose of determining the feasibility of projects under contemplation. If construction results, this account shall be credited and the appropriate plant and equipment account charged. If the work is abandoned, the charge shall be to Account 266, Balance of Earned Surplus.

152. Miscellaneous Deferred Debits

This account shall include all debits, not elsewhere provided for, the proper final disposition of which is uncertain, and unusual or extraordinary expenses, not included in other accounts, which are in process of being written off.

Liabilities and Other Credits

200. LONG-TERM DEBT

This account shall include the face value of unmatured bonds which have been issued and have not been retired or canceled.

201–219. Various Individual Bond Issues

220. SHORT-TERM DEBT

This account shall include the face value of various forms of indebtedness payable within two years from revenues or budget provisions or refundable by the issuance of long-term bonds, such as bond anticipation notes, revenue anticipation notes, capital notes and budget notes.

230. CURRENT AND ACCRUED LIABILITIES

231. Accounts Payable

This account shall include all open accounts payable by the water system within one year which are not provided for in other accounts.

232. Miscellaneous Deposits

This account shall include all amounts deposited with the municipality by customers as security for the payment of bills or as other form of guarantee.

233. Taxes Accrued

This account shall be credited during each accounting period with the amount of taxes accrued during the period, but payable in a subsequent period. Such credits may be based upon estimates, but as the facts become known, the amount of the periodic credits shall be adjusted so as to include as nearly as can be determined in each year the taxes that are applicable.

234. Interest Accrued

This account shall include the amount of interest on long-term debt and other liabilities of the water system, accrued to the date of the balance sheet but not payable until after that date.

235. Redemption of Bonds Accrued

This account shall include the accrued portion of the total amount of principal of bonds to be redeemed during the year which is not payable at the date of the balance sheet.

236. Miscellaneous Current and Accrued Liabilities

This account shall include miscellaneous liabilities which are current or which have accrued but are not payable at the date of the balance sheet.

240. Deferred Credits

241. Customers' Advances for Construction

This account shall include such advances by customers for construction as are to be refunded either wholly or in part. When a customer is refunded the entire amount to which he is entitled, according to the agreement or rule under which the advance was made, the balance, if any, remaining in the account shall be transferred to Account 261, Contributions in Aid of Construction.

242. Miscellaneous Deferred Credits

This account shall include advanced billings and receipts and other deferred credit items not provided for elsewhere, amounts which cannot be entirely cleared or disposed of until additional information has been received and amounts which should be credited to income or to surplus accounts in the future.

250. Reserves

251. Reserve for Depreciation of Plant and Equipment

This account shall be credited with the amounts representing currently accruing depreciation on plant and equipment as charged to Account 475, Depreciation. This account shall be charged with the amount carried on the books for items of plant and equipment retired and with the cost of their removal, and shall be credited with the salvage realized and any other amounts recovered, as from insurance.

252. Miscellaneous Reserves

This account shall include all reserves other than for depreciation and shall be kept or supported in a manner to show the amount of each separate reserve and the nature and amounts of the debits and credits.

260. Surplus

261. Contributions in Aid of Construction

This account shall include non-refundable donations or contributions in cash, services or property from corporations, individuals and others for the construction and extension of water facilities.

262. Special Assessments

This account shall be credited with the amounts received from assessments against customers covering the cost of construction of plant and equipment built and installed under the special assessment procedure provided by law.

263. Premiums on Bonds

This account shall be credited with all premiums received from the sale of bonds.

264. Long-Term Debt Redeemed

This account shall include the amounts of long-term debt that are redeemed from net income and charged to Account 483, Redemption of Bonds.

265. Plant and Equipment Charged to Net Income

This account shall be credited with the cost of plant and equipment which is paid for from net income and charged to Account 484, Capital Outlays from Water Revenues.

266. Balance of Earned Surplus

This account shall be credited with the Balance of Income in Account 490 in each accounting period.

Income Accounts

Revenues

300. Sales of Water

301. Metered Sales to General Customers

This account shall include revenues from measured water supplied for resi-

dential, commercial or industrial purposes where the total charge is, or may be, in any way dependent on the quantity of water delivered. The records supporting this account shall show separately, for residential, commercial and industrial sales, the quantity of water sold and the revenues on each rate schedule.

301A. Residential
301B. Commercial
301C. Industrial

302. Flat Rate Sales to General Customers

This account shall include revenues from water supplied for residential or commercial purposes where the charge is not dependent in any way on the quantity of water delivered but is based on a rate per year (or other time unit) per fixture, per foot of frontage, or other similar unit.

302A. Residential
302B. Commercial

303. Private Fire Protection

This account shall include revenues from water supplied for fire protection to customers other than public authorities, and billed under distinct private fire protection rate schedules.

304. Metered Public Use (Optional as Memorandum)

This account shall include the charge for water furnished to other departments of the municipality. If charges are not actually rendered to the departments, this account shall constitute a memorandum account of the water service furnished free to the taxpayers of the municipality.

305. Public Fire Service

This account shall include revenues from taxes or fire protection charges levied by the municipality or from other municipalities or other subdivisions or agencies of state and federal governments for use of hydrants or other fire protection facilities and for water delivered for fire service.

305A. To Owning Municipality
305B. To Outside Municipalities

306. Sales to Other Public Authorities

This account shall include revenues from water supplied to municipalities or other subdivisions or agencies of state or federal governments, under special contracts, agreements or rate schedules applicable only to public authorities.

307. Sales to Other Water Utilities

This account shall include revenues from water supplied (including standby or breakdown service) to private water utilities or to other public authorities for redistribution.

308. Miscellaneous Water Sales

This account shall include revenues from water furnished to builders, contractors, circuses and other customers who use water for a limited time without permanent connections.

320. OTHER REVENUE

321. Customers' Forfeited Discounts and Penalties

This account shall include the amounts which the municipality allows its customers on condition that they pay their water bills on or before a specified date, and which are forfeited by customers because of failure to pay within the specified time, or the penalties imposed by the municipality on its customers because of failure to pay bills within a specified time.

322. Special Services to Customers

This account shall include such items of revenue as fees and charges for connecting, disconnecting and storing of meters, special readings of meters, and for the cessation and restoration of service, including shut-off and turn-on charges.

323. Merchandise and Jobbing (Net)

This account shall include net revenues derived from the sale of water merchandise. To this account shall also be

credited the revenue from piping and other jobbing work performed by the municipality for its customers, including charges made for installing meters owned by customers and for tapping mains and laying services when the cost of such work is not includible in Account 113, Services. This account shall be charged with the cost of jobbing work, including shop expenses, transportation, stores and other applicable expenses.

324. Miscellaneous Revenues

This account shall include revenues incidental to water operations not includible in any of the foregoing accounts, including profit on the sale of unused materials and supplies not ordinarily purchased for resale; commissions on sales or distribution of others' water; and sales of ice, trees, fruit, crops and similar products. This account shall be charged with the cost of harvesting, cutting and marketing such ice, trees, fruit, crops and similar products.

Expenditures and Income Deductions

400. SOURCE OF SUPPLY EXPENSES

401. Operation of Source of Supply Plant

This account shall include the pay of employees operating source of supply facilities and the cost of the supplies consumed and expenses incurred.

402. Maintenance of Source of Supply Plant

This account shall include the pay of employees or others engaged in making repairs to source of supply property, such as reservoirs, dams or wells. This includes, in addition to labor on actual repairs, such work as routine inspection and testing, replacing or adding minor items of plant, locating and clearing troubles, restoring the condition of damaged property, the cost of materials and supplies used and the expenses incurred in repair and maintenance.

403. Water Purchased for Resale

This account shall include the cost at the point of delivery of water purchased for resale. This includes charges for readiness to serve and the portion applicable to each accounting period of annual or other payments for the right to divert water at the source of supply.

410. PUMPING EXPENSES

411. Operation and Maintenance of Pumping Equipment

This account shall include the pay of employees engaged in operating power and pumping equipment and the maintenance of this equipment, the book cost of which is included in Accounts 109A to 109E, inclusive.

412. Power Purchased for Pumping

This account shall include the cost of power purchased which is used for the operation of pumping equipment. This includes the cost of electricity or the cost of steam purchased for water pumping operations.

413. Pumping Supplies and Expenses

This account shall include the cost of fuel and supplies consumed and the expenses incurred in the operation of power and pumping equipment.

414. Operation and Maintenance of Pumping Stations

This account shall include the cost of the operation and maintenance of buildings, structures, fixtures and improvements at pumping stations, the book cost of which is included in Account 105, Pumping Stations.

420. PURIFICATION EXPENSES

421. Operation and Maintenance of Purification Equipment

This account shall include the pay of employees engaged in the operation of the purification system and the cost of maintenance of structures, apparatus and equipment used in purification activities,

the book cost of which is included in Account 110, Purification Equipment.

422. Purification Supplies and Expenses

This account shall include the cost of supplies consumed and expenses incurred in the operation of the purification system.

423. Operation and maintenance of Purification Buildings

This account shall include the cost of the operation and maintenance of buildings, fixtures and improvements, the book cost of which is included in Account 106, Purification Buildings.

424. Outside Analytical Services

This account shall include the cost of services of outside chemists, bacteriologists and laboratories.

430. TRANSMISSION AND DISTRIBUTION EXPENSES

431. Maps and Records

This account shall include salaries and expenses incurred in connection with the preparation and maintenance of maps and records of the transmission and distribution system, including the cost of stationery, drawing materials and similar expenses.

432. Operation of Mains, Services and Storage Facilities

This account shall include the cost of labor and expenses incurred in the operation of transmission and distribution mains and valves, hydrants, services and storage facilities in the distribution system.

433. Removing and Resetting Meters and Other Services on Customers' Premises

This account shall include the cost of labor and materials used and expenses incurred in removing, resetting or changing the location of meters and accessory equipment located on customers' premises and in inspecting and testing plumbing and fixtures of customers and in performing other services on the premises of customers.

434. Maintenance of Reservoirs and Standpipes

This account shall include the cost of maintenance of reservoirs, standpipes and elevated tanks in the distribution system, the book cost of which is included in Account 107, Distribution Reservoirs and Standpipes.

435. Maintenance of Mains and Accessories

This account shall include the cost of maintenance of transmission and distribution mains, valves and other appurtenances, the book cost of which is included in Accounts 111, Transmission Mains and Accessories, and 112, Distribution Mains and Accessories.

436. Maintenance of Services

This account shall include the cost of maintenance of services, the book cost of which is included in Account 113, Services.

437. Maintenance of Meters

This account shall include the cost of testing, repairing and maintaining meters and related devices and appurtenances, the book cost of which is included in Account 114, Meters.

438. Maintenance of Hydrants and Accessories

This account shall include the cost of maintenance of hydrants and related devices and appurtenances, the book cost of which is included in Account 115, Hydrants and Accessories.

440. CUSTOMERS' ACCOUNTING AND COLLECTING EXPENSES

441. Meter Reading

This account shall include the pay of employees engaged in reading customers' meters, the cost of supplies and other meter reading expenses.

442. Billing, Accounting and Collecting

This account shall include the pay of employees working on customers' applications, contracts, orders, complaints, inquiries, credit investigations, billing, collecting and revenue accounting; and the cost of supplies used and expenses incurred.

450. Administrative and General Expenses

451. Salaries of General Officials

This account shall include the compensation (salaries, bonuses and other consideration for services) of officials of the municipality, properly chargeable to water operations and not chargeable directly to a particular water function.

452. Other General Office Salaries

This account shall include the compensation of employees engaged in the general offices, properly chargeable to water operations and not chargeable directly to a particular water function.

453. General Office Supplies and Expenses

This account shall include the expenses of general officials and general office employees, and the cost of office supplies and office expenses in connection with the general administrative functions of the municipality's water operations.

454. Special Services

This account shall include amounts payable to any corporation, firm or individual, other than officials and employees of the municipality, for special services to the water department, including legal, accounting and other special services and expenses.

455. Insurance

This account shall include the cost of insurance to protect the municipality against the following losses and damages:

a. Losses and damages to owned or leased property used in water operations, such as by fire, storm, burglary, boiler explosion, lightning or aircraft.

b. Protection against claims for injuries or deaths to employees or others, or damages to the property of others, including public liability, property damage, boiler, casualty and employees' liability.

c. Protection against financial losses through the actions of officials and employees.

d. Other losses which occur in connection with water operations, and payments and expenses on account of damages for non-performance of contractual obligations.

456. Pension System and Welfare Expenses

This account shall include payments by the municipality, applicable to water operations, of pensions to retired employees or contributions to a pension or retirement system operated on an actuarial basis; expenses incurred in accident prevention, welfare, educational or recreational work; cost of life insurance for employees; or costs of employees' relief or other benefits.

457. Transportation Expenses

This account shall include the cost of labor employed and expenses incurred in the operation and maintenance of transportation equipment to the extent such expenses are not allocated directly to the accounts benefited. Transportation expenses applicable to construction shall not be included in operating expenses.

458. Miscellaneous General Expenses

This account shall include such items of expense, applicable to the water department and not provided for in other accounts, as the cost of publishing and distributing annual reports; advertising notices of public hearings; association dues; contributions for conventions and meetings of the industry; fees of transfer agents and registrars of bonds; and any other miscellaneous expenses connected with the general management and not otherwise provided for.

459. Operation and Maintenance of General Property
459A. Operation and Maintenance of Office and General Buildings

This account shall include the cost of operating and maintaining general buildings and general furniture and equipment.

459B. Operation and Maintenance of Stores, Shops and Garages

This account shall include the cost of labor employed and expenses incurred in the operation and maintenance of the water storerooms, shops and garages, to the extent such expenses are not allocated directly to the accounts benefited.

459C. Operation and Maintenance of Miscellaneous Property and Equipment

This account shall include the cost of operation and maintenance of miscellaneous property not provided for elsewhere, including general equipment, the book cost of which is included in Accounts 118, Tools and Work Equipment, and 119, Miscellaneous Equipment.

460. Taxes

This account shall include the amount of such taxes, on property of the water department, as are assessed by the owning municipality, and the amount of taxes on property of the municipality located within the limits of other subdivisions of the state, which are properly chargeable to water operations. This account shall be charged, in each accounting period, with the amount of taxes which are applicable thereto, and concurrent credits shall be made to Account 233, Taxes Accrued.

470. Miscellaneous Unclassified Expenses

This account shall include the cost of labor and materials used in doing work for the municipality not connected directly with water operations but which indirectly benefit the water works system; and the cost to the municipality of vacation and sick leave payments to water department employees, not allocated directly to other accounts.

475. Depreciation

This account shall include the depreciation expense, applicable to water operations, on depreciable plant and equipment carried in Accounts 104 to 119 inclusive, for the period covered by the income account.

480. Income Deductions

481. Interest on Long-Term Debt

This account shall include in each accounting period the applicable amount of interest on outstanding long-term water debt issued or assumed by the municipality, the liability for which is included in Accounts 201–219, Bonds. The amount charged to this account shall be credited concurrently to Account 234, Interest Accrued.

482. Interest on Short-Term Debt

This account shall include in each accounting period the applicable amount of interest on outstanding short-term water debt, the liability for which is included in Account 220, Short-Term Debt. The amount charged to this Account shall be credited concurrently to Account 234, Interest Accrued.

483. Redemption of Bonds

This account shall include the amounts required to redeem long-term bonds at maturity. It shall be charged in each accounting period with the amount applicable thereto, and concurrent credits shall be made to Account 235, Redemption of Bonds Accrued.

484. Capital Outlays from Water Revenues

This account shall include the cost of labor and materials used in constructing replacements, reinforcements and extensions of plant and equipment to the extent that such costs are to be provided for directly from water revenues.

490. Balance of Income

This account shall include, in each accounting period, the amount of income, after all deductions, available for transfer to Account 266, Balance of Earned Surplus.

Scarsdale, N.Y., Water Dept.

Balance Sheet as of February 28, 1946

Acct. No.		
	Assets and Other Debits	
	PLANT AND EQUIPMENT	
101	Organization	$ 36,950.88
105	Pumping Stations	46,447.96
107	Distribution Reservoirs and Standpipes	177,632.79
109B	Electric Pumping Equipment	49,836.49
110	Purification Equipment	2,891.10
111	Transmission Mains and Accessories	207,330.40
112	Distribution Mains and Accessories	922,472.06
113	Services	90,160.50
114	Meters	58,367.91
115	Hydrants and Accessories	11,155.55
116	Office Furniture and Equipment	1,595.99
117	Transportation Equipment	5,525.36
118	Tools and Work Equipment	5,116.06
		1,615,483.05
	CONSTRUCTION WORK IN PROGRESS	
121–129	Various Projects	22,006.65
	INVESTED AND SPECIAL FUNDS	
132	Miscellaneous Special Funds	4,109.77
	CURRENT AND ACCRUED ASSETS	
141	Cash	125,332.80
142	Working Funds	1,000.00
143	Notes Receivable	8,800.00
144	Accounts Receivable	7,041.53
145	Accrued Water Revenues	10,000.00
146	Materials and Supplies	36,811.82
		188,986.15
	TOTAL ASSETS AND OTHER DEBITS	$1,830,585.62
	Liabilities and Other Credits	
	LONG-TERM DEBT	
201–205	Various Bond Issues	$ 372,250.00
	CURRENT AND ACCRUED LIABILITIES	
231	Accounts Payable	5,145.93
234	Interest Accrued	3,595.63
		8,741.56
	DEFERRED CREDITS	
241	Customers' Advances for Construction	1,920.77
242	Miscellaneous Deferred Credits	2,189.00
		4,109.77

	Reserves	
251	Reserve for Depreciation of Plant and Equipment	235,570.85
	Surplus	
261	Contributions in Aid of Construction	190,965.40
262	Special Assessments	19,507.92
263	Premiums on Bonds	23,828.89
264	Long-Term Debt Redeemed	707,750.00
265	Plant and Equipment Charged to Net Income	102,042.31
266	Balance of Earned Surplus	165,818.92
		1,209,913.44
	Total Liabilities and Other Credits	$1,830,585.62

Scarsdale, N.Y., Water Dept.

Profit and Loss Statement for Year Ending Feb. 28, 1946

Acct. No.		
	Revenues	
	Sales of Water	
	Metered Sales to General Customers	
301A	Residential	$123,825.65
301B	Commercial	11,492.68
	Public Fire Service	
305A	Village of Scarsdale	32,707.17
305B	Outside Municipalities	2,631.00
306	Sales to Other Public Authorities	1,275.96
307	Sales to Other Water Utilities	2,025.87
308	Miscellaneous Water Sales	147.37
		174,105.70
	Other Revenues	
321	Penalties on Arrears	441.04
322	Special Services to Customers	790.50
323	Merchandising and Jobbing	477.10
324	Miscellaneous Revenues	415.22
		2,123.86
	Total Revenues	$176,229.56
	Expenditures and Income Deductions	
	Source of Supply Expenses	
403	Water Purchased for Resale	$ 51,500.87
	Pumping Expenses	
	Operation and Maintenance of Pumping Equipment	
411A	Ardsley Road Station	88.66
411B	Fenimore Road Station	139.50
	Power Purchased for Pumping	
412A	Ardsley Road Station	4,327.00
412B	Fenimore Road Station	266.00
	Pumping Supplies and Expenses	
413A	Ardsley Road Station	216.71
413B	Fenimore Road Station	133.87
	Operation and Maintenance of Pumping Stations	

414A	Ardsley Road Station	254.84
414B	Fenimore Road Station	33.46
		5,460.04
	Purification Expenses	
424	Analytical Expenses	410.21
	Transmission and Distribution Expenses	
431	Maps and Records	2.70
432	Operation of Mains, Services, Storage Facilities	2,380.10
433	Removing and Resetting Meters	232.41
434	Maintenance of Reservoirs and Standpipes	110.35
435	Maintenance of Mains and Accessories	607.40
436	Maintenance of Services	400.49
437	Maintenance of Meters	2,055.70
438	Maintenance of Hydrants and Accessories	121.15
		5,910.30
	Customers' Accounting Expenses	
441	Meter Reading	1,923.19
442	Billing and Accounting	6,020.80
		7,943.99
	Administration and General Expenses	
451	Salaries of General Officials	13,198.20
452	Other General Office Salaries	6,547.69
453	General Office Supplies and Expenses	633.53
454	Special Services—Auditing	650.00
	Insurance	
455A	Public Liability	170.15
455B	Workmen's Compensation	259.73
455C	Surety Bonds	97.50
456	Contributions to State Retirement System	2,986.42
457	Transportation Expenses	689.90
	Operation and Maintenance of General Property	
459A	General Building	1,360.39
459C	Miscellaneous Equipment	917.87
		27,511.38
460	**Taxes**	1,172.43
470	**Miscellaneous Unclassified Expenses**	2,089.65
475	**Depreciation**	14,805.91
	Total Operating Expenses	$116,804.78
	Net Income	$ 59,424.78
	Income Deductions	
481	Interest on Long-Term Debt	$ 18,180.41
482	Redemption of Bonds	40,750.00
484	Captital Outlay From Water Revenues	1,703.50
		$ 58,930.41
490	**Balance of Income**	$ 494.37

Experiences With Standards for Water Services

By Marsden C. Smith

A paper presented on Nov. 14, 1946, at the Virginia Section Meeting, Richmond, Va., by Marsden C. Smith, Chief Engr., Dept. of Public Utilities, Richmond, Va.

STANDARDS for water services in Richmond, Va., were adopted concurrently with the writing of a paper on that subject, published in June 1944 (1). Since that time, the practical use of these standards has permitted an appraisal of their value and has also dictated certain modifications in their application.

Standard Minimum Pressure

In justification of the use of standards, reference was made in the paper to an analogous situation in electrical utilities, where much confusion and waste had been avoided by rigid standardization of power frequencies and voltages in all systems. It was argued that, for much the same reasons, each water system should establish a minimum "standard" pressure, recognizing, however, that varying conditions in different systems would probably require different methods for the determination of the actual pressure to be selected as "standard." As an example, the paper described in detail the reasoning that led Richmond to select 35 psi. at the street level as its standard minimum pressure.

The city does not guarantee that pressures will never be less than the minimum standard. It does, however, obligate itself to maintain this minimum pressure throughout the distribution system. In other words, if pressures are repeatedly less than the minimum, it is the city's obligation to determine and provide means, as soon as it is practical to do so, by which the pressures may be maintained at or above the standard minimum.

If, on the other hand, a customer complains that, although pressures were once satisfactory, he now experiences difficulty due to lower pressures; and the pressures are shown to be above the standard minimum, it becomes the customer's responsibility to provide his own means for increasing the pressure within his premises.

The results of this standardization of the minimum pressure have been extremely helpful to architects, engineers, master plumbers and others interested in the proper design of the water system on the customer's premises. For example, the engineers designing the water system for an office building found that the existing pressures were sufficient to serve the proposed building, but that the standard minimum would not supply enough pressure. Therefore, the engineers designed the system so that house pumps and storage tanks could be added in the future, if they became necessary. By this plan, which was made possible because of their knowledge of the standard minimum, they were able to provide for the future installation of special equipment at a fraction of the

cost that would have resulted had not such provision been made.

It should be realized, of course, that pressure losses within the distribution system and differences in ground elevations make it impossible to maintain the minimum pressure throughout the system without an average pressure considerably in excess of the minimum.

Basis of Service Design

Since the pressure in the mains is subject to losses in the service and the meter, it is obvious that both services and meters must be carefully designed so that the residual pressure available within the premises shall be reasonable. Hence it became necessary, first, to define what constituted a reasonable residual pressure within the premises and then to allocate to the service and meter their proper proportion of the available pressure loss.

Since a vast majority of all building structures in Richmond are of three floors or less, it is evident that a delivered pressure which would adequately serve the normal three-floor elevation would successfully serve a vast majority of the city premises.

Having established, at the street level, the minimum pressure of 35 psi., the following rationing of this pressure was adopted:

	Head Allocation *ft.*	*Equivalent Pressure* *psi.*
Service and Meter	16.2	7.0
Building Piping	10.0	4.3
Residual Pressure at Outlet	10.0	4.3
Static Elevation of Outlet Above Street	44.7	19.4
TOTAL	80.9	35.0

Thus, any outlet for which a 4.3 psi. residual pressure is sufficient can be installed up to a level of 44.7 ft. above the street.

Having allocated to the service pipe and meter a loss of 7 psi., it became necessary to determine the rate of flow that should be used as a basis for calculating this loss of pressure. Obviously, the diversity in the use of the various water outlets within the premises had to be taken into consideration, as well as the differences in rate of flow from outlets used for different purposes.

The introduction of such diversity factors made it possible for an actual use within the premises to exceed the quantity assumed for the purpose of design. Every effort was made, however, to determine a diversity factor which would indicate a rate-of-flow use that, although not requiring an excessively large service and meter, would still not be exceeded so frequently in practice that it would produce an unsatisfactory flow within the premises.

Residential Service Design

Since by far the greater number of installed services were for residual uses of three floors or less, it became possible to prepare tables by means of which the proper size of meter and service pipe could be selected, and which were not too involved for practical use.

Table 1 is now used in Richmond for residential services, in which the length of the service pipe and the water-using appliances within the residence are the controlling factors. If the flushometer rather than the standard tank toilet is used, Table 2, instead of Table 1, must be used.

The instructions accompanying these tables provide that the length of the service, when from a street less than

TABLE 1

Meter and Pipe Sizes for Residences Using Tank Toilets

Group No.	Fixtures Proposed or Installed	Size of Service*	Length Range	Size of Service*	Length Range
		in.	*ft.*	*in.*	*ft.*
1.	1 toilet, 1 hydrant	$\frac{5}{8}\times\frac{3}{4}$	to 225		
2.	1 toilet, 1 kitchen sink	$\frac{5}{8}\times\frac{3}{4}$	to 105	$\frac{5}{8}\times 1$	106–280
3.	1 bath, 1 kitchen sink	$\frac{5}{8}\times\frac{3}{4}$	to 95	$\frac{5}{8}\times 1$	96–190
4.	1 bath, 1 kitchen sink, 1 furnace, 1 or more sill cocks†	$\frac{5}{8}\times\frac{3}{4}$	to 95	$\frac{5}{8}\times 1$	96–170
5.	1 bath, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 extra lavatory and toilet	$\frac{5}{8}\times\frac{3}{4}$	to 45	$\frac{5}{8}\times 1$	46–150
6.	2 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks	$\frac{5}{8}\times\frac{3}{4}$	to 45	$\frac{5}{8}\times 1$	46–130
7.	2 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 extra lavatory and toilet	$\frac{5}{8}\times 1$	to 110	$\frac{5}{8}\times 1\frac{1}{4}$	111–300
8.	3 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks	$\frac{5}{8}\times 1$	to 95	$\frac{5}{8}\times 1\frac{1}{4}$	96–275
9.	3 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 laundry tub	$\frac{5}{8}\times 1$	to 90	$\frac{5}{8}\times 1\frac{1}{4}$	91–185
10.	3 baths, 2 kitchen sinks, 1 furnace, 1 or more sill cocks, 1 laundry tub	$\frac{5}{8}\times 1$	to 55	$\frac{5}{8}\times 1\frac{1}{4}$	56–100
11.	3 baths, 2 kitchen sinks, 1 furnace, 1 or more sill cocks, 2 laundry tubs	$\frac{5}{8}\times 1\frac{1}{4}$	to 50	$1\times 1\frac{1}{4}$	51–195
12.	3 baths, 2 kitchen sinks, 1 furnace, 1 or more sill cocks, 2 laundry tubs, 1 extra lavatory and toilet	$1\times 1\frac{1}{4}$	to 85	$1\times 1\frac{1}{2}$	86–175
13.	1 bath, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 laundry tub	$\frac{5}{8}\times\frac{3}{4}$	to 55	$\frac{5}{8}\times 1$	56–160
14.	1 bath, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 extra lavatory and toilet, 1 laundry tub	$\frac{5}{8}\times\frac{3}{4}$	to 45	$\frac{5}{8}\times 1$	46–130
15.	2 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 laundry tub	$\frac{5}{8}\times\frac{3}{4}$	to 45	$\frac{5}{8}\times 1$	46–130
16.	2 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 extra lavatory and toilet	$\frac{5}{8}\times 1$	to 110	$\frac{5}{8}\times 1\frac{1}{4}$	111–300
17.	3 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 laundry tub	$\frac{5}{8}\times 1$	to 95	$\frac{5}{8}\times 1\frac{1}{4}$	96–275

* Size of meter used, with larger size service pipe.

† Built-in lawn sprinklers are not included with sill cocks.

100 ft. wide, is found by adding 25 ft., and when from a street more than 100 ft. wide, by adding 50 ft. to the distance from the property line to the back of the house. When the service is from an alley in the rear, 15 ft. is added to the distance from the rear property line to the rear of the house.

These instructions further provide that a "hydrant" is not a fire plug but is of the yard, frost-proof or plain type, and that a "bath" includes a toilet, a lavatory, a tub or shower or combined tub and shower. The instructions also provide that a 1-in. meter with a $1\frac{1}{2}$-in. service pipe may be used for any of the flushometer toilet installations shown in the table, provided a 15-gal. air-water storage tank is installed on the premises. The department warns

TABLE 2

Meter and Pipe Sizes for Residences Using Flushometer Toilets

Group No.	Fixtures Proposed or Installed	Size of Service*	Length Range	Size of Service*	Length Range
		in.	*ft.*	*in.*	*ft.*
101.	1 toilet, 1 hydrant	1×1½	to 115	1×2	116–300
102.	1 toilet, 1 kitchen sink	1×1½	to 115	1×2	116–300
103.	1 bath, 1 kitchen sink	1×1½	to 105	1×2	106–280
104.	1 bath, 1 kitchen sink, 1 furnace, 1 or more sill cocks†	1×1½	to 105	1×2	106–280
105.	1 bath, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 extra lavatory and toilet	1×1½	to 75	1×2	76–145
106.	2 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks	1×1½	to 75	1×2	76–145
107.	2 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 extra lavatory and toilet	1½×2	to 200		
108.	3 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks	1½×2	to 200		
109.	3 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 laundry tub	1½×2	to 200		
110.	3 baths, 2 kitchen sinks, 1 furnace, 1 or more sill cocks, 1 laundry tub	1½×2	to 200		
111.	3 baths, 2 kitchen sinks, 1 furnace, 1 or more sill cocks, 2 laundry tubs	1½×2	to 200		
112.	3 baths, 2 kitchen sinks, 1 furnace, 1 or more sill cocks, 2 laundry tubs, 1 extra lavatory and toilet	1½×2	to 160		
113.	1 bath, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 laundry tub	1×1½	to 75	1×2	76–145
114.	1 bath, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 extra lavatory and toilet, 1 laundry tub	1×1½	to 75	1×2	76–145
115.	2 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 laundry tub	1×1½	to 75	1×2	76–145
116.	2 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 extra lavatory and toilet	1½×2	to 200		
117.	3 baths, 1 kitchen sink, 1 furnace, 1 or more sill cocks, 1 laundry tub	1½×2	to 200		

* Size of meter used, with larger size service pipe.
† Built-in lawn sprinklers are not included with sill cocks.

against relying on this method to supply the heavy demand of flushometers, however, because of the difficulty in keeping such tanks properly charged with air.

A city ordinance provides that, for the installation of new services in which the meters are not larger than 2 in., the property owner shall pay at a flat rate. It provides further that, after the service and meter have been installed, the maintenance and replacement (but not the enlargement) shall be done by the city at its own expense.

Table 3 is a schedule of these standard charges, including all of the work done between the main and the property line, regardless of the type of pavement or the length of the service. This simple method permits a rational

design of a service and its meter for the conditions under which it is to function by the simplest practical means.

Non-residential Service Design

To assist in designing services for apartment buildings and commercial and industrial customers, Tables 4 and 5 and Figs. 1, 2, 3 and 4 have been prepared. By means of these, the assumed rate of consumption of water that should properly be used for the

TABLE 3

Schedule of Charges

Size of Meter *in.*	Size of Pipe *in.*	Charge*
5/8	3/4	$45
5/8	1	47
5/8	1 1/4	50
1	1 1/4	67
1	1 1/2	75
1	2	108
1 1/2	2	135
1 1/2	3	165
2	2	265
2	3	320

* These are the total charges made by the city for furnishing and installing water services of various sizes between the main and the property line, regardless of location in the city, the type of street or alley or the actual cost to the city.

purpose of design is determined in terms of flow in gallons per minute. Here, too, the distance from the main to the point of the first branch in the service is established and, by reference to the curves, the most economical combination of service pipe and meter sizes can be selected.

In practice, the plumber informs the department of the number and type of appliances to be installed and the distance from the property line to the first branch pipe from the service. The department then analyzes this information to determine the proper size of service pipe and meter. For example, if ten commercial kitchen sinks, four lavatories, three tank toilets and two coffee urns are to be supplied, the number of outlets and the maximum flow in gallons per minute are found by

TABLE 4

Demand and Load Factor of Various Fixtures

Fixture or Appliance	No. of Outlets	Flow *gpm.*
Domestic kitchen sinks	2	5
Commercial kitchen sinks	2	7
Shower or shower and tub combined	2	6
Tub or tub and shower combined	2	6
Lavatory	2	4
Tank toilet	1	4
Domestic laundry tubs	1	3
Sill cocks	1 (Max.)	3 (Max.)
Furnace connections	0	0
Steam table sinks	1	6
Soup kettles	2	20
Coffee urns	1	5
Potato peeler	1	8
Dish washer	2	8
Glass washer	2	6
Slop sinks	1	3
Drinking fountains	0	0

Supply to Flushometer Toilets and Urinals

No. of Units	Flow to Toilets *gpm.*	Flow to Urinals *gpm.*
1 or 2	30	2
3 to 5	45	4
6 to 15	60	6
16 to 30	75	8
Over 31	90	12

multiplying the number of units by the corresponding numbers in Table 4. For this installation, the number of outlets is found to be 33, and the maximum flow is 108 gpm. Table 5 gives the multiplier for 33 outlets as 0.34, which, multiplied by 108 gpm., indicates, for the purpose of design, a flow

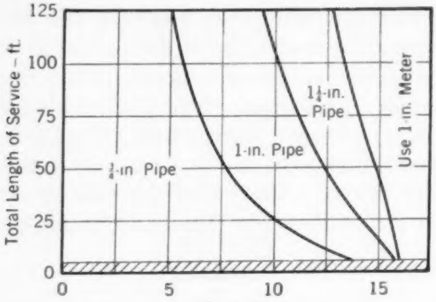

FIG. 1. Conditions for Use of ⅝-in. Meters

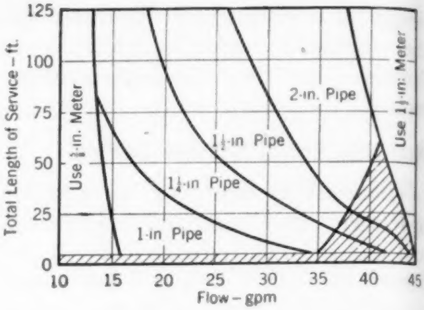

FIG. 2. Conditions for Use of 1-in. Meters

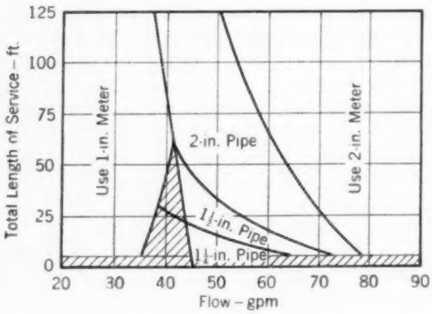

FIG. 3. Conditions for Use of 1½-in. Meters

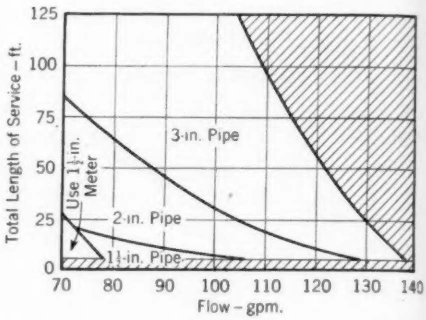

FIG. 4. Conditions for Use of 2-in. Meters

STATEMENT OF COST OF WATER SERVICE
CITY OF RICHMOND, VIRGINIA

№ 1200

Date October 8, 1946.

To supply water to premises known as:
6248 - 50 - 52 West Doe Street

to be used as a 3 residences each to be fitted with:

1 Sink	1 Hose Connection	Potato Peeler	Slop Sink
2 Shower-Tub	1 Heating	Dish Washer	Flushom. Toilet
2 Lavatory	Yard Hydrant	Glass Washer	Flushom. Urinal
2 Tank Toilet	Soup Kettle	Steam Table	
1 Laundry Tub	Coffee Urn	Drinking Fount.	

with service pipe length property line to first riser 60 feet will require for each a service consisting of 1" inch pipe and a 5/8" inch meter at a unit cost of $ 47.00 or a TOTAL cost of $ 141.00, when installed by the city in accordance with the city ordinances.

CITY OF RICHMOND, VIRGINIA

Subject to change without notice 60 days after date.

By SPECIMEN ONLY
Director, D. P. U.

Plumber: John Doe & Co.
6200 North Doe Street

FIG. 5. Cost Estimate Form Issued to Plumber

of 36.7 gpm. With the total length of service from the property line to first branch assumed to be 75 ft. and adding 25 ft. for street width; reference to Fig. 2 shows that a 1-in. meter with a 2-in. service pipe will be required. Table 3 shows the installed cost of this service to be $108.

Large Service Design

If the design estimate of the quantity of water that will be used exceeds the capacity of a 2-in. meter, a special study is necessary. The principle is exactly the same, and the service and meter are designed to deliver the estimated quantity of water with not more than a total of 7 psi. pressure loss. Generally, it has been found most economical to allocate to the meter a loss of approximately 5 psi. and to the service a loss of 2 psi. This allocation of a greater loss to the meter than to the pipe not only has the advantage of resulting in the lowest initial cost, but

TABLE 5

Load Factor Multipliers

Total No. of Outlets	Multiplier	Total No. of Outlets	Multiplier	Total No. of Outlets	Multiplier
1	1.0	18	0.22	40	0.34
2	0.72	19	0.21	42	0.34
3	0.635	20	0.22	44	0.34
4	0.575	21	0.22	46	0.34
5	0.520	22	0.24	48	0.34
6	0.465	23	0.26	50	0.33
7	0.415	24	0.28	55	0.32
8	0.375	25	0.30	60	0.31
9	0.345	26	0.32	65	0.30
10	0.32	27	0.33	70	0.29
11	0.32	28	0.33	75	0.28
12	0.28	29	0.34	80	0.27
13	0.26	30	0.34	85	0.26
14	0.25	32	0.34	90	0.25
15	0.24	34	0.34	100	0.23
16	0.23	36	0.34	Over	
17	0.22	38	0.34	100	0.22

also permits a later increase in the quantity of water to be delivered, if found necessary, by the simple expedient of enlarging the meter.

There are, of course, many other uses of water to be provided for than those listed in the standard tables. The procedure is to determine the amount of water expected to be required by the standard listed outlets, and to add the quantity to be required by any other water-consuming use. The total is, for the purpose of design, the quantity used.

The exact quantity of water required for some fixtures—lawn sprinklers, for example—is often not known at the time of application for service. When this occurs, the city determines the quantity of water required by the standard appliances, employing the previously described methods, and will use the best information available to estimate the additional water demands, so as to design the service for the total quantity. To protect the city against claims for too small a service, however, the service is rated in terms of the flow that can be delivered to a stated distance within the property line with a residual of 28 psi.

All pressure losses are based on the required use of copper service pipe up to and including the 2-in. size. For 3-in. and larger services, cement-lined, emulsion-treated, mechanically joined cast-iron pipe is specified.

Cost Considerations

A city ordinance requires that it shall be the responsibility of the Utilities Dept. to determine the size of service pipe and meter, and the city must, at its own expense, replace with a service of adequate size any service constructed under its approval that

proves too small for the demands. This regulation, designed to protect the customer, makes it necessary to record all official designs of services made by the city. Figure 5 shows the cost estimate that is issued to the plumber by the department upon information furnished by him.

tion upon which the service is designed is, to the best of his knowledge and belief, correct. Thus, the responsibility for any error can immediately be fixed. If the service is too small because added equipment has been installed, it obviously is the responsibility of the customer or plumber to pay for

APPLICATION FOR WATER SERVICE
CITY OF RICHMOND, VIRGINIA **Nº 1100**

Application is hereby made for water service to the premises known as:
6248 - 50 - 52 West Doe Street

to be used for a 3 residences each to be fitted with:

1 Sink	1 Hose Connection	Potato Peeler	Slop Sink
2 Shower-Tub	1 Heating	Dish Washer	Flushom. Toilet
2 Lavatory	Yard Hydrant	Glass Washer	Flushom. Urinal
2 Tank Toilet	Soup Kettle	Steam Table	
1 Laundry Tub	Coffee Urn	Drinking Fount.	

The pipe length from property line at point of service entrance to the back wall of building will be 60 feet.

I certify, that I know of no other connections or water use fixtures or outlets to be installed now or at a later time; and also that I know the charge made by the city for installing services is affected by the length of service and the number and type of fixtures to be supplied.

John Doe & Co.
Licensed Plumber

By SPECIMEN ONLY

RECEIVED OF JOHN DOE & CO. $ 141.00,
for payment in full of 3 1" inch service with 5/8" inch meter to supply, as provided by city ordinances, each of the above premises when equipped with the fixtures listed in the above application.

CITY OF RICHMOND, VIRGINIA

Date 10/8/46 194 By Specimen only
Cashier

FIG. 6. Receipt for Payment of Installation Cost

When applying for a water service, the plumber presents this cost estimate to the City Collector with his payment. The Collector, using the form shown in Fig. 6, issues a receipt on which he transcribes the data as it appears on the cost estimate.

It should be noted that the plumber is required to certify that the information upon which the service is designed

any necessary enlargement. But if an error is made by the city in determining the proper size of service or meter, it is clearly the duty of the city to correct the error at its own expense.

The city ordinances also require that all work, of which the customer is required to bear the cost, be paid for in advance. For that type of work and

for meter size combinations included in the flat rate schedule, payment is made and a receipt issued at the time of application. For services requiring meter and pipe sizes in excess of those in the flat rate schedule, the procedure is as follows:

After receipt of the information, which permits the quantity and the distance to be determined, the proper type and size of meter, as well as the size of the service pipe, is selected, and an estimate of the cost of the installation is made by the city and furnished to the plumber. Upon application for the service, the plumber deposits with the City Collector an amount equal to the estimated cost of the service, and any difference between the actual and estimated costs of the installed service is entered in the owner's account.

Results of Service Design

As frequently occurs, the entire idea of the city's undertaking the design of all services brought forth objections from almost every side. The plumbers resented the routine that would be necessary for its execution. The various city departments objected to the additional responsibility and "red tape." Others, with no little justification, criticized application of the same charge for a short service under an unpaved street as for one that had to be installed under wide, heavily paved boulevards.

But now, two years after its inauguration, it is doubtful whether a single group is not greatly pleased with the results of the plan. The design method has prevented the frequent installation of services either too large or too small for the purposes intended. This was an improvement, not because the plumbers were dishonest or ignorant, but simply because no one realized the importance of correct design of the water services. As errors in the design of the size of services and meters could not be discovered until after the plumber and the city had been paid for the installation, it became virtually impossible for the customers to obtain redress. This frequent cause of contention is now entirely eliminated by first making sure that the service is correctly designed and then definitely fixing the responsibility for any error.

It is interesting to note how much more water can be delivered through a given meter by the use of a larger service pipe, causing a relatively small increase in the total installed cost of the service. The plumbers are to be commended for so frequently taking advantage of this basic fact, which they had never realized until the standards were adopted.

Also, since the greater part of services installed are covered by the flat charges, both the contractor and the owner know in advance the exact charge the city will make for the water service. This permits exact estimates and avoids the possibility of error in the amount charged by the contractor against the owner for the city's part of the work.

It can truthfully be said that had this system always been used, many thousands of dollars would have been saved both the city and the customers. The saving in money, reduction of service complaints, and removal of the inconvenience forced upon customers, because of too low and too variable water pressures within their premises, have certainly repaid the effort required to develop the standards for water services in Richmond.

Reference

1. ANON. Standards for Water Service. W.W. & Sew., **91**: 191 (1944).

Useful Life of Water Wells

A Panel Discussion by James C. Harding, E. W. Bennison, J. Arthur Carr, Angus D. Henderson, Arthur T. Luce, John B. Millis, Harrison E. Romine and Leon A. Smith

A condensation prepared by James C. Harding, Westchester County Comr. of Public Works, White Plains, N. Y. and Co-chairman, Committee 4A—Deep Wells and Deep-Well Pumps, of six papers presented on May 9, 1946, at the Annual Conference, St. Louis, Mo. The original papers were by E. W. Bennison, Office Engr., Edward E. Johnson, Inc., St. Paul, Minn.; J. Arthur Carr, Eng. & Supt., Dept. of Water Supply, Ridgewood, N. J. and Co-chairman, Committee 4A—Deep Wells and Deep-Well Pumps; Angus D. Henderson, Civ. Engr., New York City Dept. of Water Supply, Gas and Electricity, Bayside, N. Y.; Arthur T. Luce, Chief Engr., New York Water Service Corp., New York; John B. Millis and Harrison E. Romine, Engrs., State Water Survey Div., Urbana, Ill.; and Leon A. Smith, Supt. of Water Works, Madison, Wis.

THE comments of Carr relate largely to rock wells in northern New Jersey; of Luce and Henderson, to sand and gravel wells in Long Island; of Smith, to rock wells in Wisconsin; of Millis, to various types of wells in Illinois; and those of Bennison, to wells in general.

Because of the necessity of saving space, and because some of the material submitted, although excellent, was not germane to the subject, considerable material has been eliminated.

The table and figure prepared by Millis, as well as the comments of the other authors, present a rather startling indictment of past and present practices in the design, construction and operation of municipal well supplies. The urgent need for more study of this subject, and for giving wide publicity to proper methods of well construction and operation, is clearly indicated. The stress placed by the various authors on the dangers of overpumping is novel in water works literature and should cause every operator of a municipal well supply to think over his own operating procedures carefully.

Causes of Well Failures

Receding Water Table

SMITH: At Wauwatosa, Wis., just outside of Milwaukee, the ground water level 30 years ago was approximately 80 ft. above the level of Lake Michigan. It is now 70 ft. below. Thus, there has been a drop in the ground water level in rock wells of 150 ft., making it quite clear that in the Milwaukee area water is being taken out of the ground faster than it is being replenished.

MILLIS: If water level recession could be eliminated, there would apparently be no limit to the useful life of a properly constructed and operated sandstone well, except for occasional

clean-outs and replacements of liners. Recession necessitates continually lower pump setting in straight holes of larger diameter.

Overpumping and Obsolescence

CARR: The error of attempting to wring the last drop of water from a well is common. Overpumping wells in a consolidated formation usually does not result in permanent damage to the well, but, in an unconsolidated formation, it frequently necessitates making difficult and costly repairs and often causes the total loss of the well.

MILLIS: The primary cause of failure of sand and gravel wells is overpumpage of the well, of the well field or of both. The end result is complete clogging of the well screen or the surrounding water-bearing formation. There are records of farm wells that have been in active service for more than 50 years with no more attention given to them than the occasional replacement of pump leathers. This indicates that casing and screen corrosion is not (in Illinois) a primary cause of failure. In other areas where large diameter gravel-packed screened wells are developed and pumped at near maximum capacity from the day they are put in service, and where there is known to be an ample supply of water, failure sometimes can (and often does) occur in less than a year.

It has been found that wells generally fail as a result of chemical, bacterial and mechanical clogging of the screen and surrounding formation. Overpumpage is therefore defined as the rate of pumping which accelerates the clogging process. No figure can be given as the limit of safe production, a greater rate than which is overpumpage. Optimum yield can only be determined by analysis of costs, the history of retired wells and the present condition of active wells. Engineers are as yet unable to predict with any degree of accuracy what a desirable and safe yield from any particular well or group of wells may be, but they should all be able to determine if a well is being grossly overpumped.

Any well that has a portion of the screen exposed to air during pumping periods is being overpumped. Any well which has the pump suction pipe set below the top of the screen is offering a standing invitation to overpumpage. At times it may be more economical to pump wells at high rates of production and pay for more frequent replacement than to expend more money in first cost for a larger number of wells and pumps. Each problem is different and should be regarded as such, but, today, too many individuals and organizations are losing money by overpumping their wells.

BENNISON: Many wells are reduced in capacity in a relatively short time and are eventually ruined by overpumping. To consider the chemical reactions between the metals used in well construction and the effect of air both in and out of the water being pumped on these metals, is to have the answer to the causes of corrosion and incrustation and also the remedy —a reduction in the pumping rate. Improper control of pumps often results in large quantities of water flowing back into a well under a high head, causing upsets in chemical and hydrostatic conditions within the circle of influence, the deposition of the products of corrosion and incrustation on pump parts and on the interior of the well, to say nothing of the continual surging effect to which the well is being subjected. This continual upsetting of the hydrostatic conditions in

and around a screened well often leads to sand infiltration or sand pumping as well as incrustation.

SMITH: Overpumping is a difficult thing to define in rock wells. In Madison, Wis., it was concluded that if the water level is not drawn more than 60 ft. below the static level, the well is not being overpumped.

All of the twelve wells which were originally drilled in Madison have been abandoned, largely because they were only from 4 to 8 in. in diameter and were too small to permit the use of modern efficient pumping equipment.

HENDERSON: There is a loss of useful life and a lessening of value which takes place because of service changes, such as the necessity of furnishing larger quantities of water by constructing additional wells in the vicinity or the pumping of water against increased pressures, thus reducing the capacity of the existing pumps.

Faulty Design and Construction

BENNISON: Not only ability to resist corrosion and incrustation but strength should be taken into account when specifying construction materials to be used in wells. Many wells collapse because screens or casings are too light to withstand lateral pressures, shifting strata and the weakening effects of corrosion and erosion.

It is believed that the careful selection of screens, with properly shaped openings and sufficient open area per foot of length, contributes more to the life of a well in unconsolidated formations than anything else.

HENDERSON: Care in specifying the type of materials used can do much to extend the useful life of the entire structure. Good practice in large diameter wells now consists in placing a 2-in. cement coating outside the casing for its entire length, after the casing has been placed. The additional useful life secured is not yet known.

Incrustation and Corrosion

LUCE: A review of the troubles encountered in maintaining the yield of all types of wells in unconsolidated formations shows that with very few exceptions they have been due to screen stoppage. Screens in tubular wells that have been pulled show a hard crustation of sand and gravel over the screen openings. Most of these screens have been cleaned and replaced. Even a few "Miller" screens have responded to this treatment but the gauze in most of them was destroyed in the cleaning process and they had to be replaced by "Cook" or "Johnson" screens.

HENDERSON: Certain types of water and soil attack casings and screens very rapidly. In some, extra heavy wrought-iron pipe may fail in 7 to 15 years. In others, the same casing will still be in good condition after more than 30 years of service.

The same corrosive properties of waters which cause them to attack casings also affect screens. On Long Island, salt intrusion caused a few screens to go completely to pieces within six months from the time they were first placed in use, whereas others have been withdrawn which were still in good condition after 40 years in the ground. Here again the proper selection of materials for the particular type of water can do much to lengthen the life of the entire structure.

BENNISON: Failures of casings and screens from corrosion and incrustation are most frequently encountered and certainly affect the useful life of water wells.

MILLIS: It was found essential to prevent iron-bearing water under a

high hydrostatic head from entering a deep sandstone well. During idle periods, when iron-bearing water enters the well, the iron is oxidized by contact with air in the upper part of the well and when downward movement occurs this iron compound is deposited in the sandstone. This has been very effective in sealing off the sandstone. In some places a highly mineralized and corrosive water is present in the upper formation. With either condition (and one or the other always exists) it becomes imperative to pressure grout a string of pipe from below this zone to the surface.

HENDERSON: Artificial gravel wall wells normally fail either by sanding or from incrustation of the screen. Sanding is probably almost entirely due to inadequate or improper development at the time of construction, although it may sometimes be traced to faulty selection of the screen slot or the size of gravel packing used.

Rehabilitation of Failed Wells

BENNISON: Shooting is the most commonly used method of restoring the yield of rock wells, and acid treatment is used the most to restore screened wells.

SMITH: The usefulness of a rock well can sometimes be restored by blasting. In one typical instance, shooting with 80 per cent high velocity gelatine was resorted to on a well, drilled in Madison shortly before 1930, which showed progressive reduction in capacity. The first shot was 25 lb., the second 50 lb. and the third and subsequent shots were each 200 lb. It is desirable to use smaller shots at the beginning because, if the sandstone formations are too soft, it is sometimes impossible to bail out the hole. After this well was shot, bailed out and efficient pumping equipment installed, it was possible to pump at the rate of 4 mgd., with less drawdown than originally occurred when the well was being pumped at a 3-mgd. rate.

Occasionally the sandstone formations are so soft that the cementing material holding the particles of sandstone together washes out, causing the well to produce sand. This happened to the Main Station Well at Madison, which was drilled in 1934. Shooting was not practicable because of the possibility of losing the hole entirely. The sand pumping was eliminated by the use of a screen of copper-bearing metal set in the well from the bottom of the hole to the bottom of the eduction pipe. The annular space between the screen and the open hole was filled with gravel. Granite type gravel was used so that acidizing could be resorted to, if necessary, in the future. This procedure eliminated the sand, although the capacity of the well was reduced about 10 per cent.

CARR: A few years ago the water pumped from one of the newer, double-cased, Ridgewood, N.J., wells showed frequent discoloration for short periods of time. As there was no wash under the casing, it was concluded that the discoloration was due to a sloughing off of rock and shale from the well wall, probably caused by wash as the water raised and lowered in the well, and by exposure of the wall to the air. Although the efficiency of the pumps or yield of the well had not been affected, it was decided to correct the condition if possible. The pump was removed, and the well subjected to treatment by a method considered new to rock holes.

The entire well wall was first scrubbed to remove all adhering loose particles of rock, shale or clay. The

scrubbing was done with a heavy brush made up of ¼-in. steel bristles. The well was then subjected to vigorous agitation or development. To accomplish the development a plugged nipple, of slightly less diameter than that of the well, was attached to a steel cage 20 ft. long. At the top of the cage a hook wall packer was placed, and the entire assembly was lowered to the bottom of the well on a string of 8-in. pipe. There the packer was expanded against the well wall. A long, heavy, steel plunger or piston was then operated inside the 8-in. pipe. As the packer at the top of the cage and the nipple at the bottom acted as plugs, all of the action or surge was concentrated on the 20 ft. of well wall exposed by the cage. At intervals the packer was released and the cage raised until all of the well wall had been exposed to development.

All heavy sand and pieces of rock or shale dislodged by the violent motion of the water were caught in the nipple, which acted as a trap at the bottom of the cage. Surprising amounts of loose material were brought in by this method. Once 4 cu.yd. of sand, clay and rock particles were dislodged and removed from a 12-in. well 350 ft. deep.

Prolonged tests disclosed that, not only had troubles from discoloration been eliminated, but the yield of the well had been materially and permanently increased. Because of the results obtained with this well, two other wells completed in 1932 were treated by the same method and the yield of each was increased more than 100 per cent.

Blasting or shooting has proved of little value in increasing or restoring the yield of rock wells in northern New Jersey. Its use has frequently resulted in decreased rather than increased yields.

Henderson: Incrustation of the screen can usually be corrected by the use of inhibited acids and by redeveloping the well. After 10 to 15 years of use a surprisingly large proportion of wells develop sand trouble to such an extent that the only means of correction is the placing of a liner screen. The placing of this liner is not only a costly operation in itself but also materially reduces the yield of the well.

Luce: Remedies used to restore lost yield of wells in unconsolidated formations have varied. They include blowing with air, surging by intermittent pumping with a turbine pump, brushing, acid treatment, agitation with a plunger or combinations of these methods.

Life of Rock Wells

Millis: The records of more than 100 sandstone wells selected at random were examined. Unless retirement occurred in less time, only wells drilled more than 10 years ago were considered. Of the 79 well records which were tabulated, 58, or more than 70 per cent, are still in service. One well has been in service 58 years, and 12 wells have been in service more than 40 years. The average age of the wells is 27 years. Twenty-one wells have been abandoned for various reasons. One well had been in service 56 years when it was retired, and the average life of all abandoned wells was 36 years. Available data indicate that average life of unprotected casings and liners is about 25 years. More data must be examined, however, before that can be made a positive statement.

The records of 83 municipal limestone wells drilled before 1935 were

examined. The 62 wells still in service have an average age of 20 years. One well has been in service 52 years. Twenty-one wells were abandoned for the following reasons:

Small diameter or crooked hole	12
Casing failure (avg. life 30 years)	4
Iron bacteria clogging	3
Miscellaneous	2

In the few wells where bacterial clogging has been noticed, the use of hydrochloric acid has been very effective in restoring the wells to their original capacity. Where this trouble exists, failure occurs in 10 to 15 years.

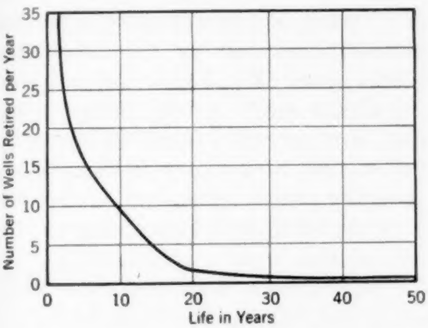

FIG. 1. Mortality Rate of Sand and Gravel Wells

CARR: No failures due to collapsed casing in the rock holes of northern New Jersey have been noted. In some single cased wells, in which the water above the rock is high in chlorides, particularly in the vicinity of Newark Bay, casings have deteriorated until leakage has occurred.

There are many rock wells in northern New Jersey 50 or more years of age that have been in continuous use with no apparent decrease in yield. Eight wells in Ridgewood drilled in 1900 have been in constant operation since that time and are still producing satisfactorily.

BENNISON: A recent check with three large midwestern railroads and three reliable and experienced well drilling companies, all of them over 50 years old, revealed that practically all wells still in operation after 50 years are rock wells.

SMITH: From the experience in Madison, it appears that wells can be developed which will have a useful life well in excess of 50 years if a large drive pipe is installed, in which is set a well casing approximately 6 in. smaller in diameter, and the annular space filled with cement grout. Two wells drilled in 1910 with steel casings without grout protection corroded through in less than 10 years.

Life of Gravel Wells

MILLIS: Table 1 is based on an examination of the histories of 320 municipal wells, selected at random, in Illinois. The wells were constructed in sand and gravel. Figure 1 shows their mortality rate.

TABLE 1

Service Record of 320 Wells in Illinois

Well records examined	320
Wells abandoned	285
Wells still in service	35

Causes of Failure or Abandonment

Poor mineral quality	1
Crooked hole	1
Pump and tools dropped in hole	1
Collapse of concrete screen	1
Casing failure (after 18 years)	1
Screen clogging and incrustation	280

Life of Wells

Wells still in service	*Years*
Avg. life	14.8
Max. life to date	32.0
Abandoned wells	
Avg. life	6.1
Max. life	45.0
Min. life	1.0

LUCE: Gravel-packed wells are generally constructed by sinking an outer casing to the top of the water-bearing formation and installing in this a smaller inner casing with a screen section at the bottom. The size of the openings in this screen are generous (⅛ to ¼ in.), and dependence for keeping out the sand is placed on the gravel that is introduced between the inner and outer casing. These wells are generally large, ranging from 16 to 26 in. in screen diameter and, if properly constructed, will show no appreciable falling off in yield after many years of operation unless the screen is affected. Observations on 26 wells of this type ranging in age from 10 to 26 years and in capacity from 1,000 to 2,400 gpm. show that all of them are capable of yielding large quantities of water.

Older wells that have fallen off in yield have generally been remedied by redevelopment or acid treatment. One well installed in 1924 showed an increase in specific capacity of 25 per cent at the end of 20 years with no treatment in all that time; two others, 18 years old, have the same specific capacity as when installed. Several have fallen off in yield or given trouble due to faulty construction. On the whole, however, it is believed that this type of well, properly constructed and operated under the conditions that obtain on Long Island, should have a life of 75 years with screen cleaning and redevelopment when specific capacity drops seriously.

Tubular wells constructed for operation as individual units have been put in a class by themselves as they are generally larger than group suction wells and their yield is readily obtainable from records of pumpage. Observations have been made of 21 wells of this type. Two are 6 in., two 10 in., two 16 in. and fifteen are 12 in. in diameter. Their ages range from 2 to 19 years; the average is 10. Most are operated by motor-driven turbine-type pumps. There has been no marked falling off in yield of any of these wells. They are all of standard construction—steel casings with bronze screens. The oldest well now has a specific capacity of just half its original amount, but it was redeveloped once before and it is quite possible that it could be again, and its original capacity restored. As the use of the well has been curtailed, however, this is hardly necessary. With proper maintenance these wells should have a life of 50 years, and others built under the specifications used on the later wells of this group should exceed this figure.

Tubular wells, group-suction operated, are generally found in the original design of a water works. They generally consist of a group of 6- or 8-in. wells all operated by a common direct suction from a steam pump. As the plant grows, more and more wells are added. It has been possible to get reasonably accurate data on many of the 339 wells of this type in 11 well fields. Most of the older wells were constructed with "Miller" screens (brass gauze wrapped around a perforated brass pipe), and are still in use although practically all of the original screens had to be replaced by the "Cook" or "Johnson" screens after 15 to 25 years. The average age of these wells is 40 years, and individual ages range from 4 to 52 years. Assuming that probably 25 per cent of these wells are not yielding a reasonable amount and would not respond to redevelopment, the useful life of this type of well may be considered to be about 30 years.

HENDERSON: Only a few tubular wells will fail in the first 10 years; the

average life is at least 20 years. Sufficient length of experience is not available to forecast the life of gravel-packed wells but it is believed one-half of the value is gone in 15 years. Poorly constructed wells in corrosive water might fail in 5 years, whereas a properly constructed well, adequately maintained and pumping non-corrosive water, should still be serviceable after 50 or more years.

BENNISON: Many wells have been inspected, both rock and screened, that were over 50 years old, but there are also many wells which should have lasted 50 years but which failed in a relatively short time. There is no reason why wells cannot be so constructed as to increase the average useful life of screened wells to 50 years and rock wells to 100 years. There are reports of screened wells over 50 years old, but these are exceptional. The average life of screened wells under all conditions seems to be from 25 to 30 years.

Avoiding Failure of Gravel Wells

LUCE: Perhaps a few words gained from experience with these wells may be of assistance in pointing out ways and means to avoid unusual maintenance or failure of wells:

Tubular Wells

1. Take core samples of the formation at intervals of 5 ft., or when the formation changes, in advance of driving the casing to get a true sample. Keep pint samples in sealed jars.

2. Drill a test well not less than 6 in. in diameter to determine formation, yield and water quality before any large well is drilled. Time and expense may be saved by sinking the full size casing in the top part of the hole if the location of the waterbearing formation is known. If this is done, the large casing can be stopped well above the formation and the test hole extended below this point.

3. Select screen size and location after a sieve analysis of samples, as it is frequently advisable to use more than one size of slot.

4. Study carefully the formation above where the top of screen is to be located, as some of it will come down opposite the screen area.

5. Select a screen of generous length if the history of the locality indicates screen stoppage.

6. Develop the well by agitation with a plunger in the casing, alternately bailing and pumping and surging with a turbine type pump of a capacity at least 30 per cent in excess of the proposed operating rate of the well. This development should continue until the well is sand-free.

7. Allow sufficient lap in casing pipe when changing to smaller sizes and also at the screen.

8. Casing should be standard drive pipe with recessed couplings.

9. Install screen by the "jack-back" method in order to avoid damaging it.

Gravel-Pack Wells

In constructing gravel-pack wells, most of the preceding recommendations should be carried out, in addition to the following:

1. Use casing of proper thickness, $\frac{3}{8}$ in. recommended. Welded or riveted joints are acceptable, but shop tests should be made to check workmanship. This is especially true if the well is to be deep. Failures can be due both to split casings and screens.

2. Proper selection of screen slot and length should be made.

3. Gravel should be well rounded and selected in accordance with the slot opening and formation in which the screen is set.

4. Under-reaming the well will insure a more even distribution of gravel around the screen.

5. Keeping the bottom of the outer casing approximately 5 ft. above the top of the screen will prevent cutting off of the gravel by the sand in the formation and a possible break-through at this point.

6. Gravel should be kept in the annular space between outer and inner casing just below the pumping level of the water in the well.

7. If the rotary process is used to sink the well, the material used for sealing the formation should be of the lightest possible consistency, in order to insure its removal during development. Loess has been found to be most satisfactory as it is much more readily removed than clay.

Erratum

In Fig. 4 of the paper, "Ground Water Conditions at Charleston, W.Va.," by Russell M. Jeffords and R. L. Nace, Vol. 38, p. 1313, Nov. 1946 JOURNAL, the labeling of the ordinate was in error. *For* "Parts per Million" *read* "Equivalents per Million."

Aspects of Public Relations

By Philip B. Niles, William H. Ogden and Elon P. Stewart

A panel discussion presented on Oct. 4, 1946, at the New York Section Meeting, Albany, N. Y., by Philip B. Niles, Asst. Vice-Pres., Water Works Service Co., New York; William H. Ogden, Pres., South Bay Consolidated Water Co., Glen Cove, N. Y.; and Elon P. Stewart, Dept. of Eng., Div. of Water, Syracuse, N. Y.

Relations With Customers—*Philip B. Niles*

PUBLIC relations is an outgrowth of the Industrial Revolution, an attempt to solve the frictions and misunderstandings that inevitably arise whenever large groups of people live and work together in a free society. To succeed, public relations activities must be reasonably persuasive; they must convince people that the agency doing the persuading is a beneficial unit of society and should be retained.

When a railroad company changes its timetable, thousands of people may be affected. Usually, if the railroad takes the trouble to explain to its customers why the change is being made, gives them sufficient notice, and does a reasonably persuasive job, the public will accept the change with good grace. If, on the other hand, the railroad merely announces the change with no explanation, leaving many people stranded, perhaps, and all forced to adjust their schedules to an apparently arbitrary and irrational whim, a first class public relations problem will have been created. Furthermore, if the railroad pursues its way through the years merrily creating similar problems, no matter how excellently it may be run in other respects, eventually the public will find some effective way to manifest its disapproval. Competing lines or modes of transportation may be used, a friendly public will be wanting when regulatory legislation is being considered—in one way or another, the railroad will suffer.

Everyone has had disagreeable experiences with sales clerks, waiters, cashiers and others who neglected their public relations jobs. Just imagine all that ill will directed against one's own water utility! The public relations problem is more acute, however, for a public utility, whether privately or publicly owned. When the customer is not free to vent his dissatisfaction by turning to a competitor, his sense of outrage will be multiplied. If, over the years, the water utility produces too many dissatisfied customers, the public will eventually have its revenge. It is surely entitled to it.

For this reason, every organization dealing with large groups of people must consider public relations a necessary business procedure. This is not to say that every water works needs a full-time public relations man, but cer-

tainly someone in the organization—and at the executive level—should be charged with the responsibility for this function.

The aim should be to convince the public that the water works system is an efficient, courteous and up-to-date utility. This cannot be accomplished, however, by the efforts of one man alone, for what is done at one level is all too easily undone at another. Every employee can produce good will; he is equally capable of engendering ill will. Executive management, through its planning and policies, can make friends or it can make enemies. Without a conscious orientation toward the task of maintaining good public relations, one result may follow as easily as another.

The managements of the electric, gas and telephone utilities are noted for the particular effort and care which they take of their relations with the public; and to the extent that the water utility will be compared to them, it must be considered in competition with them. The public is not going to make allowances and tolerate less courtesy and consideration from the water works because it may be a public venture. The wise executive considers public relations to be a very definite part of the utility service which it renders to the public.

Of course, good public relations presuppose good service. Unless the standards of modern and efficient water service are maintained, public relations are bound to be a problem. The province of public relations activities is to make the public aware of the quality of the service it is receiving; they may thereafter condition it to accept the occasional nuisance of service interruption or impairment when a main is broken or being flushed.

Claude Robinson, who heads the Opinion Research Corp., emphasizes to his clients that they are making another product besides the automobiles, washers or kilowatt hours that may be their ostensible function. Robinson uses the term "social forms." These social forms comprise every human contact affecting the organization—relations between employee and management, management and customer, government and management and management and security holder or, for a publicly owned enterprise, taxpayer. Social forms cannot be measured with a meter, but their quality can be determined with fair accuracy through a public opinion poll. And their quality is of too great importance to any organization to be left to chance.

Relations With Employees—*William H. Ogden*

There has been an increasing trend toward unionization of water works employees, and the potential problems involved merit the attention of operators of both municipal and privately owned water plants. Efforts toward unionization are sometimes instituted by employees themselves, presumably influenced by other union activities in the community which have resulted in substantial wage increases. Perhaps more often, the union agitation is conducted by professional organizers who represent one of the two major national union groups.

To a large extent, the desires of water works employees for substantial wage increases over those existing prior to

the war period are well justified. Wages for industry as a whole are about 50 per cent higher. Based upon the best available information, the cost of living has increased slightly more than 30 per cent. Wage increases in the utility field, based upon present levels, average about 30 per cent above prewar. This is naturally less than the average for industry as a whole because of generally better working conditions and perhaps because of the reluctance of many public utility employees to participate in union organization.

The companies with which the writer is associated on Long Island became unionized in 1941 and since that time five successive annual contracts have been negotiated. Although the negotiations leading to these contracts have not always been entirely friendly, there has been a strong feeling both on the part of the management and on the part of the union that strikes should be avoided. The union leaders seem increasingly aware of the public feeling that utility strikes endanger the public health and safety and should, if necessary, be prohibited by appropriate law.

The relations between management and employees of any water system, publicly or privately owned, will necessarily affect the opinion of the public toward that water system. If employees consider that their rate of pay is inadequate or their working conditions unsatisfactory, they will undoubtedly tell their friends and neighbors of their dissatisfaction. Since the customers of the water system almost invariably feel they are paying enough to provide adequate wages to the water works employees, there will be little, if any, sympathy in the community with a management policy which holds wages below the standards set by other industries. It should be remembered that the employees of a water system greatly outnumber the managers and supervisors and, therefore, have a wider influence upon public opinion.

The general terms of the union contracts, covering the working conditions of approximately 50 employees of the water supply properties operating in Nassau and Suffolk Counties on Long Island, are given below. Some of the employee benefits specified in these contracts were provided by the companies before unionization in 1941. Others were obtained by the union in negotiations for the first contract, and still others have been added in the several contract renewals.

It is agreed by the parties that:

1. There shall be no strike or lockout during the term of the agreement.

2. The company recognizes the union as the exclusive bargaining agency for all of its employees in the job classifications specified, and all such employees are required to become members of the union within 10 days after their first employment.

3. Promotion to superior job classifications is on a basis of seniority in company employment, subject to the restriction that the management of the company must approve the qualifications of the employee applying for promotion.

4. A considerable portion of the agreement is taken up with detailed provisions for the handling of grievances. In brief, it is provided that the complaint of any employee about wages or working conditions shall be submitted through the union representative to the management for discussion. If it is not satisfactorily disposed of, the issue is submitted to arbitration. Both parties agree to abide by the decision of the arbitrator, who is to be selected by an independent organization,

such as the New York State Board of Mediation.

5. All employees receive overtime pay at one and one-half times the regular hourly rate for all hours worked in excess of 8 hours in one day, or in excess of 40 hours in one week. Employees who are called in for emergency work after regular hours receive overtime pay for a minimum of two hours.

6. All employees receive a regular day's pay for each of the eleven holidays which are legal in New York State, and, if the regular operation program requires work on such holidays, the employees receive double pay for the holiday work.

7. Employees having at least one year's service with the company receive two weeks' vacation with pay, and employees having a total of fifteen years of service with the company receive three weeks' vacation with pay.

8. Leave of absence for illness is granted with pay up to two weeks in any one contract year, and this allowance may be increased, depending upon the employee's length of service and previous record of absences.

9. If an employee is absent due to an accident covered by the workmen's compensation law, the company pays to the employee the difference between his compensation benefits and his regular wage rate for a period up to four weeks.

10. Employees are granted three days' absence with pay in the event of a death in their immediate family.

11. The company provides an opportunity for employees to subscribe to hospital service and group life insurance; but such subscriptions are voluntary on the part of the employees, and appropriate deductions are made from the paychecks to cover the cost of these services.

12. The company provides uniforms and overalls for the employees and replaces such clothing when worn out or unfit for further use. The union agrees on behalf of the employees that they are to keep the clothing clean and in good repair.

13. Employees who are absent from work on jury duty receive from the company the difference between the jury duty service fee and the regular wage rate for not more than one week in any contract year.

14. The contracts provide in some detail the work schedules for employees in various classifications. All of these schedules specify a regular work week of 40 hours, but this is divided among either five or six days per week, depending upon the duties of the various groups.

15. Wage rates vary from a minimum of 90¢ per hour for unskilled labor to $1.09 per hour for general utility men who customarily handle such work as setting and removing meters and the installation and repair of service pipes, mains and hydrants. Foremen and skilled laborers and mechanics receive wage rates which are higher in proportion to their responsibilities and mechanical ability.

Although these wage rates are approximately 50 per cent above those paid in the prewar period, they are still less than current wage rates in the area for comparable jobs in the construction field. The weekly earnings are likewise lower than those for semi-skilled employment in local industries, such as the aircraft manufacturing plants. This differential is justified, however, by the fact that the water supply industry provides exceptionally stable employment in comparison to other fields. The rates quoted are those in effect

under the existing contract which will expire in December 1946, and it is expected that a further increase may be agreed upon in next year's contract.

The additional operating costs to the company as a result of wage rate increases have been absorbed up to the present time without the necessity of increasing water rates. This has only been possible, however, because of substantial increases in revenues from water sales which have in turn been brought about by new building and increased pumpage in the area. In addition to the increased costs for wages and salaries sustained by the companies in recent years, other costs, such as for taxes and contractors' services, have risen proportionately. Increases in labor rates continue to be an important factor in the cost of new equipment and construction. Up to the present time, construction costs have increased about 40 per cent over prewar levels, and these increases continue as manufacturers, suppliers and producers of raw materials adjust their wage scales to the new standards. In the final analysis, the cost of everything we buy depends upon labor.

Relations With the General Public—*Elon P. Stewart*

It is generally conceded in water supply circles that the public knows little of its water system and the problems of its operation. It has been said that one never misses the water until the well runs dry, and this old axiom is equally true of the public water supply. People do not miss the water until it fails to come from the faucet and, therefore, do not do much thinking about it nor care much about how it gets there.

It might well be asked: "Why should they?" The best answer to this question for municipally owned systems is that every user is an owner, in part at least, of the system, and everyone should be familiar with his own property. From the standpoint of the water works operator, dealings with the customers of the system will be easier if they understand the problems involved in serving them.

The water supply system always receives a great deal of newspaper publicity when something unpleasant or annoying has happened to the water service. More recently, radio stations have been reporting on municipal affairs and, of course, water comes in for its share of this type of publicity. Unless carefully planned measures are taken to supply information on how efficiently a system normally works, therefore, the public will be exposed only to the unfavorable publicity which attends breakdowns and other troubles.

The author has found that both newspapers and radio stations are very willing to accept and publish interesting facts on the water supply system—especially incidents which are of human interest. Water works officials by all means should see to it that such stories are given to the public by these agencies several times a year.

Frequently the water system is asked for information and descriptive literature by students in grammar school, high school and even college. There is no better way of acquainting the public on any subject than to introduce it into the home through the medium of the child or young adult.

The Syracuse Water Div. is now planning to design and make available

for distribution a bulletin on its water supply system containing all of the data which are pertinent for study in schools and other information which is of general interest to the public. This bulletin will be well illustrated with photographs of interesting features of the system and with simple graphs and diagrams explaining its workings.

A few years ago, the division made a color motion picture of the most interesting features of the water works, including action pictures of maintenance and operation procedures. A prepared script read during the picture, when properly synchronized, gives about the same effect as a sound film. The preparation of this reel, which is run in about eighteen minutes, was not expensive. It provides interesting and attractive publicity for the water system, and has been shown on many occasions to water works meetings, schools, nursing classes and social clubs. It has been well received and is one of the best means available for acquainting the public with the water supply system and its problems.

The author believes that water superintendents and engineers should welcome every opportunity to speak publicly about their water supplies. The public is invariably interested in these talks and is always amazed at the details which are involved in operating a water system.

Selecting, Training and Rating Personnel

By Stephen C. Casteel

A paper presented on Oct. 15, 1946, at the Southwest Section Meeting, Galveston, Tex., by Stephen C. Casteel, Resident Engr., East St. Louis & Interurban Water Co., East St. Louis, Ill.

THE application of employee training to the water supply industry can and should increase the output of individuals—always the goal of progressive management. Increasing individual output means that:

1. Supervisors and workers engaged in the maintenance and operation of the physical plant be made more cognizant of the necessity for increased efficiency of plant and equipment.

2. All customer-contact employees increase their output of good-will to gain and hold good public relations.

During today's inflationary trends, water works management must of necessity be geared to utilize efficiently fuel, chemicals, pipe, lead and other materials that must be purchased at inflated prices. Of course, the increased cost of labor itself is significant. When costs increase and production decreases, someone is certain to suffer, and ultimately everyone is affected.

Personnel management did not enter the industrial scene as a social service to any faction. It has a definite function, sometimes described broadly as "the efficient utilization of the human resources of industry."

Industry cannot expect to utilize fully the aptitude, skill and talent of workers if no organized plan or system is followed in the selection, placement and training of personnel. Employee training has, to some extent, been used over a period of years, and the records disclose some failures as well as successes. Where failures occurred, it was the method that failed, not the basic principle. Too often in the past a training program may have been instituted as a benevolent but ineffectual gesture toward employees.

A training program should not be applied for the specific purpose of creating or maintaining the good-will of employees. The objective is simply to encourage people to do a better job at their every-day work. When this is accomplished, the benefits resulting will be enjoyed mutually by employees and management. It is, of course, logical to assume that a well-informed person is more likely to be a satisfied and efficient worker than one who is not.

How does one proceed to install a training program for an average water supply operation? Before this question may be answered, something should be known of the personnel included in the program. If the author's experience is typical, a number of new employees are entering the field.

Considerable care should be exercised in the selection of new employees to assure good material for future training. In hiring help, fanciful intuition and the hunch method are usually employed. In selecting personnel, the tools employed are the interview and the judicious use of certain tests.

A fundamental concept held by personnel management is that each job should present an opportunity to utilize the capacities and satisfy the interests of the worker. Such an ideal condition is seldom found. It is not at all difficult to find a worker who is maladjusted, who retards output and lowers employee morale. To a large extent, such a condition can be corrected by applying selection technics to procurement, following up with a practical system of training.

Selection

The purpose of the interview is to secure and impart information. The employer wants to determine the qualifications of the applicant; the applicant has the same privilege of learning something of the policies of the company or department. The interview should be a friendly exchange of information in pleasant surroundings. The day of the "take it or leave it" attitude is over. The progressive employer, therefore, does not "hire help" but selects personnel on the basis of appraising the ultimate value of the prospective employee.

The applicant, if worthy of his hire, is keenly interested in what opportunities for growth the position offers. He is concerned, and rightly so, with his future recognition and security.

Testing

Pre-employment tests are valuable personnel tools. However, good judgment is necessary to administer and appraise the tests. Proper tests are useful only as a means to an end; they are not themselves substitutes for intelligent selection. Each individual possesses certain ambitions, emotions, degrees of alertness and other characteristics which can be fitted to a specific job, although not as accurately, of course, as a pin may be fitted to a machine. When a position is to be filled, the specific requirements of the vacancy should be ascertained and possible promotions to the job should be visualized. This procedure enables the interviewer to predetermine the qualifications necessary to man the position effectively.

When the new employee is finally selected, placement becomes important. Entering a new organization is not a simple procedure for many people. By all means there should be conveyed to the employee the feeling that he is welcome, that his services are needed and that his employer is extremely desirous that he progress to the ultimate of his capacity and interest.

Training

The general method of training follows the same pattern for new and old employees, with the exception of a short period of indoctrination training for the new employee. For over 15 years the author has closely observed the results of training applied to the water works industry at several widely separated localities. In each attempt, increased efficiency has been achieved, and at the same time employee morale was improved. This was accomplished by inspiring team work to encourage co-operative effort and also by giving prompt recognition to individual performance.

The lecture-conference method was used at East St. Louis to present prepared material to steam plant operating staffs. An introductory series of ten papers was given, which covered the following sequence of subjects: boilers, boiler appurtenances, boiler room equipment, heat (two papers), energy, workpower and combustion and pressures

(two papers). The class assembled weekly to cover the material of each paper. At the conclusion of this series, an examination was given, and copies of the papers were given the class members for future reference. Later the work was resumed by presenting an additional 20 papers at weekly intervals, covering the various subjects more adequately.

Several incidents resulted from this work which gratified the sponsors. Four men passed the examination for steam engineers required by the city license board, thus acquiring their licenses. Two who later entered the armed services reported that the training work assisted them in their service examinations. One man who entered the Navy requested evidence he had attended the classes and, of course, it was furnished.

There is a great deal of educational work on purification being accomplished by the sanitary engineering bureaus of a number of state boards of health, and all four states of the Southwest Section of the Association have excellent educational programs. Texas, under the capable leadership of Mr. V. M. Ehlers, has developed an educational and training program of the highest calibre. The splendid schools of Oklahoma and Louisiana and the unique licensing plan of Arkansas have all made noteworthy contributions to the field of job training.

Public and Customer Relations

The employees who contact the public in the average water company or department are in an outstanding position to create and maintain customer good-will. Uninformed contact personnel can inadvertently destroy the good-will that progressive management has endeavored to build. Under a well-directed training program, and with the enthusiastic support of management, contact employees should become the exponents of good-will. The customer who calls at the water office with a complaint wants an explanation in plain English of what he wants to know about meters, pipelines, turbidity, hardness, milky water or whatever else disturbs him. An unpleasant customer contact leaves a blemish upon public relations that cannot easily be erased. Such unpleasant contact can be prevented by schooling contact employees in the fundamentals of the business and of the art of human relations. The author has talked about training methods with a number of office employees, and it is his belief the majority will welcome any program that will add to their knowledge of the operation of a water supply business.

The Instructor

The success of any training program depends largely upon the ability and enthusiasm of the instructor. No person can instruct a group effectively simply because he has been ordered to do so. He must be fully convinced that his work is of value and maintain this attitude even though discouraging situations may arise. The strength and courage of one's convictions are prerequisites to success in any undertaking that has the aspect of an innovation. There is a certain reluctance on the part of some people to accept anything new.

An instructor obviously should be well prepared and understand his subject matter. It has been proved, however, that competency in one's work is not always indicative of success as an instructor. The first duty of the leader when a group is assembled is to establish an atmosphere of mutual interest.

He must remember that his group consists of average people, some of whom have come only out of curiosity. Some are only indirectly interested in self-improvement. There is always the person who, at the start, may have the idea he is better informed on the subject than the instructor. Then, too, there is the person who seeks the rear seat, shivering in his boots lest he be asked a question. He needs the instructor's protection, and, unless it is forthcoming, he will not return.

The first meeting is of vast importance. The instructor is on trial; it is his job to lead the group, each member of which responds in a different manner. The technic of scholastic teaching is not usually successful in job training. The students are adults whose chief occupation is working, not learning.

The instructor should keep before him the aim of training, which has been well described (1):

> The aim of training is to fill the gap which exists between the requirements of the job and the ability of the individual who occupies the position or who may be promoted to fill it.

Merit Rating

The results of training should be measured. This can be done by the use of a merit rating system. If this technic is applied before training is started and again at intervals, progress can definitely be measured. Of course, the value of a merit rating system depends upon the ability and attitude of the rater. He must discard all tendencies toward prejudice and partiality and be guided by facts. At East St. Louis, an objective method of rating has been employed, with some success, which depends upon eight factors:

1. Quality of work
2. Volume or speed of work
3. Knowledge
4. Dependability
5. Character
6. Capacity for growth
7. Initiative
8. Relations with employees and the public.

Each factor is rated by applying one of five grades—A–exceptional, B–above average, C–average, D–below average and E–poor.

A numerical weighting can be used with this system from which a graphic form is prepared to show the relative ratings of individuals. If $2\frac{1}{2}$ points is given to each grade, the highest grade is worth $12\frac{1}{2}$ points. A person rated exceptional on all eight factors would therefore rate 100 points or per cent. This system was applied to a typical water works operating group of 126 hourly employees, and about 70 per cent rated between average and above average.

The author considers the merit rating system most valuable. It is, of course, comparatively new, particularly so in the water works field, and the technic may be changed as experience is gained. It starts supervisors and department heads thinking in terms of people—*why* some employees do better than others. If used in conjunction with a training program, it will serve as a guide for the development and application of a practical system for the purpose of educating employees in the most efficient methods of operation.

Conclusion

In summation, the author wishes to suggest that all water works executives take stock of their own requirements. Regardless of its size, a water works

operation is a vital cog in the wheel of production. Every informed person is well aware that, on the whole, our production system is not producing as it should. The output of individuals has decreased, causing a serious economic unbalance. It is the mission of personnel management to increase production, and thus to lower unit costs. A sound personnel program will include selection technic in procuring employees, a practical method of job training and, finally, a merit rating system.

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Influence of Phosphates on Zirconium-Alizarin Method of Fluoride Determination

By Dean M. Taylor and Russell E. Frazier

A contribution to the Journal by Dean M. Taylor, Public Health Engr., and Russell E. Frazier, Chemist Aide, both of the Div. of Sanitation, State Dept. of Health, Minneapolis, Minn.

MOST of the commonly used methods for the determination of the fluoride content of water supplies are based on the decolorization of a zirconium-alizarin lake in proportion to the fluoride present. It is definitely known that iron, aluminum, sulfates and chlorides interfere with these colorimetric methods, but no specific information has been available in the past about the influence of phosphates.

Recent investigations have shown that phosphates do interfere with colorimetric fluoride determinations. This discovery was made when samples of water from a small town were being analyzed. A polyphosphate compound was being used to stabilize a ground water supply, and, when the water in the distribution system was analyzed, 2.3 ppm. of fluoride were found by the Scott modification (1) of the Sanchis method (2), although the raw well water contained only 0.2 ppm. fluoride. A sample of water from the distribution system was then distilled with sulfuric acid (3) and the fluoride content was found to be 0.2 ppm. by the Scott method. A chemical analysis of the water gave the results shown in Table 1. The chloride and sulfate concentrations were too low to interfere with the colorimetric determination, and the interference from iron was avoided by using only clear supernatant (hydrated iron oxides settled to the bottom). When phosphate concentration was investigated, it was found that the water supply operator was feeding excessive amounts of a polyphosphate compound (Nalco 918Y, distributed by The Flox Co.) into the water supply.

Some experiments were made to determine just how much phosphates interfere with the colorimetric method for fluorides. The first experiments were made using distilled water, and then the work was repeated with natural water of varying degrees of hardness.

TABLE 1

Analysis of Water in Distribution System

pH Value	7.3
Total Hardness, *ppm.*	320
Total Alkalinity, *ppm.*	390
Total Iron, *ppm.*	1.2
Manganese, *ppm.*	0.05
Chlorides, *ppm.*	4.5
Sulfates, *ppm.*	5.0

Experiments With Distilled Water

Procedure

Standard phosphate solutions were made by dissolving definite amounts of sodium hexametaphosphate ((Na-

TABLE 2

Effect of Phosphates on Fluoride Determination in Distilled Water

Phosphate Added, *ppm.*	Apparent Fluoride Reading, *ppm.*					
	$(NaPO_3)_6$	Nalco 918Y	$Na_4P_2O_7$	NaH_2PO_4	Na_2HPO_4	Na_3PO_4
1	0.05	0.05				
2	0.1	0.1	0	0.02	0	0
3	0.2	0.2				
5	0.4	0.3	0	0.1	0.02	0
7	0.7	0.55				
10	1.1	0.9	0.2	0.2	0.05	0.05
15	1.7	1.4				
20			0.38	0.35	0.1	0.1
40			0.64	0.6	0.3	0.2
60			0.88	0.7	0.6	0.3
80			1.08	1.0	0.7	0.5
100			1.3	1.05	0.8	0.8
150			1.7	1.35	1.1	0.9

TABLE 3

Analyses of Natural Waters

Sample Number	83861	83863	83864	83877	83878	83879	83880
pH Value	8.0	8.3	7.5	7.4	7.4	7.8	7.6
Alkalinity, *ppm.*	34.0	133.0	378.0	439.0	308.0	392.0	283.0
Iron, *ppm.*	0.08	0.08	0.24	4.0	0.05	0.02	0.45
Chlorides, *ppm.*	4.9	6.1	3.6	0.5	62.0	4.5	1.2
Sulfates, *ppm.*	64.0	4.7	4.7	1,570.0	500.0	219.0	2.4
Fluorides, *ppm.*	0.05	0.05	0.05	0	0	0	0
Calcium, *ppm.*	17.59	27.48	77.5	308.5	77.5	121.1	70.89
Magnesium, *ppm.*	10.57	17.33	42.5	90.8	120.4	45.75	28.35
Calculated Total Hardness, *ppm.*	87.5	140.0	369.0	1,145.0	690.0	491.0	294.0

$PO_3)_6$), sodium pyrophosphate (Na_4-P_2O_7), monobasic (NaH_2PO_4), dibasic (Na_2HPO_4) and tribasic (Na_3-PO_4) orthophosphates and Nalco 918Y in distilled water. Chemically pure salts were used, with the exception of Nalco 918Y. Definite volumes of these phosphate solutions were pipetted into 100-ml. tall-form Nessler tubes and the tubes were filled up to the 100 ml. mark with distilled water. Then fluoride readings were obtained by comparison with fluoride standards. The Scott modification of the Sanchis method was used.

Results

The results are given in Table 2, in which the amounts of phosphates added are tabulated opposite the apparent fluoride reading when using each of the indicated phosphate salts.

Some of the colored lakes which were formed when the indicator solution was added to prepared samples had a tendency to fade, making it difficult

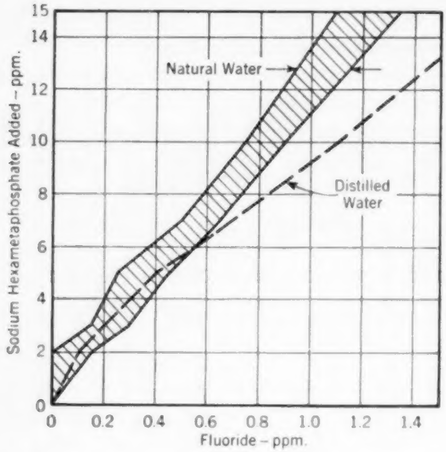

Fig. 1. Relation Between Sodium Hexametaphosphate and Fluoride Reading

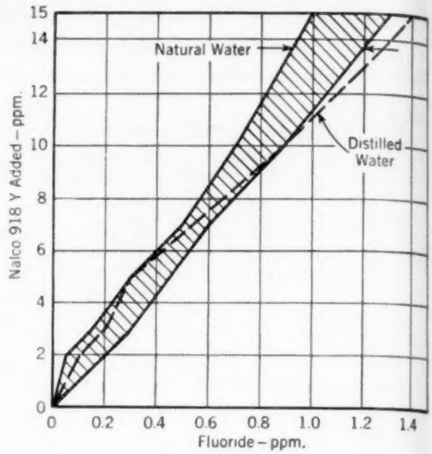

Fig. 2. Relation Between "Nalco 918Y" and Fluoride Reading

TABLE 4

Effect of Phosphates on Fluoride Determination in Natural Water

Sample Number / Total $CaCO_3$ Hardness, *ppm.*	83861 / 88	83863 / 140	83880 / 294	83864 / 369	83879 / 497	83878 / 690	83877 / 1145
Phosphate Added, *ppm.*	Apparent Fluoride Readings, *ppm.*						
Nalco 918Y							
2	0.15	0.2	0.15	0.1	0.2	0.05	0.05
3	0.2	0.3	0.25	0.2	0.25	0.15	0.15
5	0.4	0.45	0.4	0.4	0.45	0.35	0.3
7	0.5	0.6	0.6	0.55	0.55	0.55	0.5
10	0.7	0.85	0.85	0.85	0.9	0.85	0.7
15	1.0	1.25	1.3	1.25	1.3	1.3	1.15
$(NaPO_3)_6$							
2	0.15	0.15	0.15	0.05	0.15	0.05	0
3	0.25	0.3	0.25	0.2	0.2	0.15	0.15
5	0.4	0.45	0.4	0.4	0.45	0.35	0.25
7	0.55	0.6	0.65	0.6	0.6	0.6	0.5
10	0.85	0.9	0.9	0.9	0.9	0.85	0.75
15	1.3	1.3	1.35	1.3	1.35	1.35	1.1
Na_2HPO_4							
5	0	0	0	0	0	0	0
10	0.1	0.15	0.15	0.15	0.15	0.05	0
20	0.15	0.2	0.2	0.25	0.25	0.1	0.05
40	0.25	0.35	0.35	0.35	0.35	0.2	0.15
60	0.45	0.45	0.5	0.5	0.5	0.3	0.2
100	0.6	0.65	0.65	0.65	0.7	0.55	0.4

to compare colors with the standards. This was particularly true with the tribasic sodium orthophosphate solutions. Nevertheless, the results were reproducible, and all of the data were obtained by averaging at least three different sets of results.

Experiments With Natural Waters

Procedure

The same procedures were used as with the preceeding experiments, except that natural waters instead of distilled water were used in making up the phosphate solutions. The analyses of these waters are given in Table 3.

The influence of high sulfate concentrations on the fluoride reading was compensated for by adding sulfates in the form of sodium sulfate to the appropriate standards. The influence of iron was avoided by using the clear supernatant (hydrated oxides of iron settled to the bottom of the container).

Results

The results are given in Table 4, in which the amounts of phosphates added are tabulated opposite the apparent fluoride readings when the various natural waters are used in making up the phosphate solutions. These results were not exactly reproducible, but reasonably so, and the figures given represent the average of at least three results.

It was also difficult to compare the colors developed in these solutions with the color standards. In order to make the results comparable, the readings were taken exactly one hour after the indicator solution was added to the samples and standards. A noticeable precipitate of calcium and magnesium phosphates was formed when the dibasic phosphate was added to the waters of varying hardness, particularly the waters with high hardness values.

Discussion

The data indicate that the interference with the colorimetric fluoride determination is greater with the metaphosphates than with the orthophosphates. They also indicate that the interference diminishes in value with increasing hardness values of the water, probably because of the reaction of the phosphate ions with the calcium and magnesium ions. The results obtained with distilled and natural waters did agree reasonably well within the limits used, for which see the comparisons in

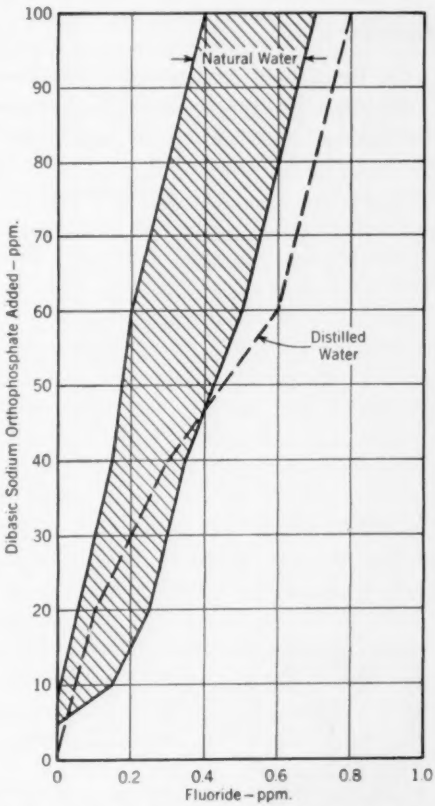

FIG. 3. Relation Between Dibasic Sodium Phosphate and Fluoride Reading

Figs. 1, 2 and 3. The limits of the results with natural waters are shown by the shaded areas and the results with distilled water are represented by the broken-line curve.

It is not very probable that appreciable amounts of phosphates, particularly metaphosphates, will be found in natural waters, but it is becoming common practice to treat water supplies with various phosphate compounds. The determination of the fluoride content of water supplies is a commonly used procedure, and, if fluorides were to be added to water supplies for the purpose of preventing dental caries, it would be necessary to have exact methods of control.

Summary

1. Phosphate compounds interfere with the colorimetric determination of fluorides in water when the zirconium-alizarin lake method is used, giving false positive results.

2. Metaphosphates interfere more with the fluoride determination than the orthophosphates do.

3. Increasing hardness values of the water decrease this interference.

Acknowledgment

The authors wish to thank Prof. A. P. Black, University of Florida, Gainsville, Fla., for his helpful criticisms and suggestions.

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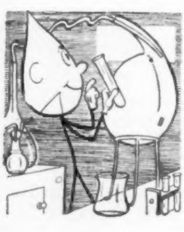

Water Works Extension Problems in 1946

By Elbert J. Taylor

A paper presented on Sept. 12, 1946, at the Western Pennsylvania Section Meeting, Pittsburgh, Pa., by Elbert J. Taylor, Chief, Bureau of Water, Philadelphia, Pa.

UNSETTLED supply and labor conditions gave the Philadelphia Bureau of Water much trouble in carrying out its construction program for water works extensions. Active preparation of detailed plans for water works improvements was begun in 1940, and at that time the cost was estimated at approximately $18,000,000. Some of the contracts for equipment and pipelines were awarded in the Spring and Summer of 1941. During 1942, contracts for more of the large improvements were advertised but the priority ratings obtainable were insufficient to justify awarding the contracts. It was necessary to revise the program, make emergency installations and carry out only the most critical parts of the reconstruction work.

Finally, after three years of priority trials and tribulations, it seemed in October 1945, with the removal of most of the restrictions, that the program could really be started. It was anticipated that materials of construction would be readily available and that labor would be plentiful. Neither of these conditions materialized. Construction materials are scarce and are getting scarcer. Skilled labor is scarce and, in general, the output per man-hour is less than it was in 1940. At the same time, the cost of materials and labor is unstable. Most materials are being quoted subject to price adjustment at time of delivery, and skilled labor in Philadelphia is generally available only when full weeks with double time for Saturdays are guaranteed by the contractor.

The city, on July 31, 1946, had outstanding contracts for water works extensions amounting to $5,700,000. Progress payments made on these contracts total $1,800,000, leaving $3,900,000 in work now under construction. In addition to this work, contracts totaling $1,000,000 have been awarded but not certified. Other contracts are about ready for advertising, so that by next spring it is expected that outstanding contracts will total about $10,000,000. The rate of construction progress compared to prewar rates is extremely slow and, except for the smaller distribution pipelines, the costs on work advertised since October 1945 have been about 70 per cent above those estimated in 1940.

The extensions now under contract include: new pumping station structures; reconstruction of pumping station structures; steel mains 60 to 42 in. in diameter; pumps, motors, transformers and switchgear; cleaning and cement lining of 48-in. steel mains; chlorination facilities; and smaller cast-iron distribution mains. Some typical contracts will be discussed in more detail to illustrate the difficulties which are being encountered.

Contracts for Mains

During the spring of 1945, a priority rating was obtained for the construction of two parallel steel mains extending from the East Park Reservoir at 33rd St. and Montgomery Ave. to the Booster Pumping Station at 33rd St. and Girard Ave. The mains vary in size from 60-in. at the reservoir to 54-in. at the booster station, and are about 3,400 ft. in length. The route lies in Fairmount Park and the lines pass under one six-track railroad and another four-track railroad.

The contract for this work was awarded on June 21, 1945. Steel plates were available from stock already rolled, because of changes in the construction program of the government, and the first pipes were delivered on November 8, 1945. Most of the straight 60-in. pipe was delivered before the steel strike, but some of the 60-in. special fittings are still undelivered and only 60 per cent of the 54-in. pipe has been delivered. In addition to the time lost during the steel strike, conditions in the fabricator's shop delayed delivery of fittings. An unusual number of oversized ends has been found so that difficulty has been experienced in applying couplings. The delay in delivery of pipe and other material and the scarcity of labor have made it necessary to store the pipe on the site for a relatively long period, during which time the coal-tar enamel coatings have suffered.

The first work scheduled to be done on the job was the installation of eight 36-in. control valves at the reservoir to replace valves installed in 1879. These had to be placed two at a time to maintain adequate service and it was expected that this part of the work would start in October and be completed in December 1945. The first two valves were not delivered, however, until November 16, 1945, and the last two were not received until May of the following year.

Two 48-in. hydraulically operated gate valves are required on the job. The first one was received July 3, 1946; the second was delivered on August 23, 1946. The delay of the second valve was due to failure of the bonnet under hydrostatic test, and the new bonnet had to await its turn in going through the factory.

Three 30-in. and two 12-in. hydraulically operated cone valves were received on April 14, 1946. The recovery cones of venturi meters in which they are installed, however, were not received until August 8, 1946. This part of the work is still delayed, awaiting some 60-in. steel specials.

It has been impossible for the contractor to prepare a construction schedule in advance and to maintain it, because of the lack of some critical material. This has, of course, increased his construction costs without corresponding compensation from the city. At the same time, during the course of construction, increases in labor cost have been necessary at various times. The most recent stoppage was due to a strike of crane operators who demanded and ultimately received a guaranteed weekly wage, including Saturdays at overtime rates, the hiring of an oiler for each crane to be on continuous duty and a substantial increase in the hourly rate of pay. In general this contract is about eight months behind schedule, in spite of the earnest efforts of the contractor to complete it.

The contract for the Parkside Ave. main was awarded July 13, 1945. This line is 6,700 ft. long and includes only a few steel specials. The steel pipe was fabricated and coated in December 1945 because the fabricator was transferring

his shop to another city and completed the contract before moving. The pipe was not delivered to the job until May 1946 when the cast-iron specials were expected. Several large tapping sleeves and valves were delivered in August, but the 36-in. line valves have not yet been delivered. The cast-iron fittings were not delivered until June 1946. The contractor for this work was allowed to defer starting installation until most of the materials were assembled; consequently, his progress has been more uniform than that of the contractor on the East Park mains. He also has been burdened, however, by a lack of skilled labor and by increased labor costs.

A contract for the construction of a steel water main, 48 and 42 in. in diameter, was awarded on August 8, 1946. The contractor advised that the steel pipe would be delivered within six months after placement of the order and that delivery of the gate valves will involve a wait of nine to twelve months. This indicates that steel plates are harder to obtain now than last year, but deliveries of fabricated pipe are expected to improve.

Small Mains

In Philadelphia small mains extensions are generally carried out under private contract. The mains are assessed at $2 per front foot, and builders are credited with assessments where they lay the mains. These mains are laid under Bureau of Water inspection. During the past two years the city has installed piping and valves at street intersections, because the increased cost of material and labor has made it impossible for the builders to lay intersections as well as the pipe along the street without paying more than the assessments.

Contractors engaged in laying these lines have ordered material ahead and so far have been able to install 6 and 8 in. mains as required. The Bureau of Water has at times loaned fittings and valves to expedite the work.

Where it is necessary to lay the smaller lines under city contracts, there is a delay of from four to six months after the notice to begin before sufficient materials are on hand to justify starting.

Pumping Station

In October 1945 a contract was awarded for the construction of a new pumping station at Torresdale. The contract price is $1,300,000. The station will house ten motor-driven pumps having a total capacity of 215 mgd. The structural steel for the superstructure was available at the time bids were received and fabrication has proceeded according to schedule. This schedule was not too ambitious, but the steel was fabricated and was delivered during September. Excavation and concrete work have been seriously delayed because of the shortage of labor. The contractor has been able to bring his carpenter force up to his minimum requirements by guaranteeing the men a 48-hour work week, with double time for Saturday; until he agreed to this arrangement, he was able to obtain only about one-fourth of the men needed.

Reinforcing steel has been available as needed. This is true for all jobs awarded last year, and there is no indication of a shortage this year.

Cement and concrete aggregate have been available as needed. The contractor has been able to obtain form lumber, including plywood, but he does not have a plentiful supply and plans to re-use it more often than usual.

Many large gate valves needed for this job are now scheduled for delivery

beginning in October 1946 and ending in March 1947.

Steel windows and doors and other superstructure items are expected in the early part of 1947. Most of the shop drawings have been approved for these items, but no definite delivery dates have been set.

The overhead traveling crane was delivered during July of this year. It has been necessary for the contractor to store this but he accepted delivery as soon as it was available, fearing that a deferment might place him so far behind in later schedules that he would be unable to obtain material when he needed it.

A contract for furnishing and installing electric motor-driven pumping units at the Queen Lane Raw Water Pumping Station was awarded on November 19, 1945. These pumps consist of four 40-mgd. units to operate at 260-ft. head and two 20-mgd. units to operate at 260-ft. head. The first 40-mgd. unit was delivered in October, and delivery of the four large units will be completed at the end of March 1947. The delivery of the two 20-mgd. units is scheduled for the end of February 1947. Considering the magnitude of the work, this is the best equipment delivery that the city has obtained.

Electrical Gear

Bids were taken on November 19, 1945, for metal-clad switchgear and transformers for the pumps abovementioned. All bids for this equipment were conditioned upon a price adjustment clause and the contract was not awarded. The electrical manufacturers indicated a possibility that they might bid at a later date without the price adjustment clause, but so far there has been no indication that they will do this. It is, therefore, planned to purchase the switchgear in the contract for wiring. This, of course, will seriously delay the installation of the pumps, but so far the Solicitor's Office in Philadelphia has not approved any contracts for which payment is based on a price adjustment clause.

On May 7, 1945, a contract was awarded for the switchgear and wiring for the installation of one 40-mgd. pump in a temporary pump house to be constructed at Queen Lane Pumping Station. In June 1945, when the order for this switchgear was placed with the manufacturer, the expected delivery date was February 1946. The switchgear was received in September 1946.

Other electrical equipment has been delayed in the same manner. One 2-hp. motor on a minor improvement that was required to be 2-phase instead of 3-phase is not expected in less than 18 months. Even small motors of conventional characteristics are delayed from six to eight months.

Causes of Difficulty

In general, the author believes that the uncertainty of scheduling work is the most serious difficulty that contractors have to deal with in bidding under present conditions. The city of Philadelphia is co-operating with contractors to the extent of including in current estimates an allowance for material delivered to the job equal to 90 per cent of the invoice cost. This has encouraged contractors to place the orders immediately and most of them have ceased to attempt to schedule the delivery of materials to, or in accordance with, the construction progress.

Contractors are also at a disadvantage in bidding on water works extensions at this time because of the probable increase in skilled labor rates and the fact that practically all material quotations are now conditioned with price adjustment clauses. The most

common form of clause seems to be a statement that the goods will be invoiced at the prevailing price at the time of shipment. The city of Philadelphia has been urged by many materials suppliers and contractors to include price adjustment clauses in contracts. So far the city has insisted that the contractors absorb these uncertainties. As long as OPA prices were in effect, this was to some extent a hardship on the manufacturer when he bid directly to the city, since he was not supposed to quote prices above the ceiling. How long the city will be able to continue this policy is questionable, but so far bids have been received for all maintenance materials required, and the city has tried to purchase switchgear only on a direct basis. So far the city has not found that an exorbitant allowance is made in the bids to take care of these special contingencies.

Some of the valve manufacturers have indicated that they would be willing to place a limit to the price adjustment clause, making the maximum adjustment 10 per cent of the bid. The electrical equipment industry proposes a maximum of 30 per cent in their suggested price adjustment clause.

It is the author's opinion that the high wages and consequent high cost of materials are due to the inflationary effects of unbalanced budget spending which has been going on in this country since 1932. The contention that an increase in prices of manufactured articles would be inflationary does not appear sound, since inflation comes from excess purchasing power with relation to the supply of goods. The cash to pay high prices is available in the country, but the urge to manufacture goods at the restricted price is not sufficient to supply the demand. So far as construction work is concerned, the high wages, high cost of materials and lower production per man-hour are, it would seem, the reasons for the increased cost. It appears unlikely that construction prices will recede until a serious economic readjustment is made, so that a deferment of needed construction would not be justified because of the price. On the other hand, water works officials who are able to defer their extensions for several years should be able to proceed on a more stable basis and save themselves many headaches. For those who are in the same position as the city of Philadelphia and are faced with the necessity of immediate extensions, the only solution seems to be to award contracts at least one year ahead of actual construction, so that materials can be assembled before the actual installation begins.

Discussion

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The author's very interesting paper has covered a subject which is not only of vital interest to all water works men but also involves the underlying conditions which affect all industries and the lives of all of us. Stripped of all verbal foliage, the cause of troublesome conditions existing at this time can be expressed by the word "inflation."

It is difficult to place one's finger upon any single cause or remedy, and certainly it would be presumptuous for the writer of this discussion even to infer that any ideas expressed by him were to be construed as those of an

economic expert. It does seem patent, however, that unbalanced budget spending is inflationary, and that it is one of the causes—if not the most direct of them—for the present high cost of materials.

It should also be pointed out that increases in labor rates that were granted with federal sanction, and at times under federal pressure, have had a marked effect upon the cost of materials. It is impossible to increase wages without incurring an increase in the cost of the products of labor. Some industries have been able to absorb increased labor costs, others have not, but regardless of such factors it has been necessary for the OPA to grant many increases to the manufacturers. These increases have caused and will cause demands for further increases in labor costs, thus setting off the vicious inflationary spiral that may be likened to a "dog chasing his tail."

That we are embarked on this upward trend seems unquestionable to any save wishful thinkers and politicians who are still talking about avoiding inflation. Inflation is already here, and what should be discussed is how to make its results as painless as possible.

One of the main reasons for the present high cost of materials is that the demand exceeds the supply. A remedy that appears to be logical is to decrease the demand. It is believed that had all wartime controls, including those on labor, been maintained until there was a reasonable balance of supply and demand in our economy, some, if not all, of the troubles now existing, and those that are ahead, might have been avoided. This measure was not taken. Instead, labor costs were, for all practical purposes, freed from control, and the dizzy inflationary flight upward began. An increase on one side of the scales calls for an increase on the other, and it seems illogical to expect a balance to be reached until the basic law of supply and demand has brought it about.

The law of supply and demand is working now, but its effectiveness is hampered by attempts to control prices by federal laws, edicts and directives. Such control has not and will not solve the problem unless it is applied to all increments of our national economy, and then only for a limited time. Ultimately the law of supply and demand will control, for its effectiveness is too inexorable to be denied. Any artificial control can only be temporary. It is the writer's belief that, although there might be a short period of confusion in some lines if controls were removed now, such a condition will follow decontrol whenever it occurs, and the sooner the law of supply and demand is allowed to control, the sooner we will establish a sound economy.

The alternative is perpetual control, which cannot itself avoid the law of supply and demand in the end. It would seem that the choice lies between a free and a controlled economy. The trouble now is that our present economy is the result of too much political thinking, rather than of sound economics.

A number of things can be done to ease the present situation in construction. Adherence to the following suggestions should be helpful:

1. The federal government should postpone all public works expenditures that are not absolutely necessary until such time as supplies of material and labor are available and costs are at least on a reasonably level plane.

2. All governmental subdivisions should follow this example.

3. Private corporations should hold to the minimum their capital expenditures for work requiring construction materials and labor, and the amount decided upon should be compatible with the requirements for modernization and the probable market for products in the near future. It is believed that, generally speaking, this suggestion is being observed now, even if involuntarily.

4. Individuals should avoid spending accumulated earnings for materials and labor which can otherwise be used to meet the demand for new homes and for necessary utility and industrial construction, both public and private.

So many water works extensions were postponed during the war that the resulting accumulation of work, much of which can be classed as vitally needed, is now being dumped upon the market. This condition is general for all industries and even for individual consumers. There is a universal accumulated demand, with an accompanying accumulation of funds with which to pay. It would seem that some regulation of the flow of materials to certain demands, especially in the construction industry, is justified until supply and demand have been brought into balance. It is the writer's belief, however, that allowing the law of supply and demand to govern prices, rather than relying upon federal control, offers the best means of bringing about that balance.

Apparently the legal department of the city of Philadelphia has ruled that the city cannot purchase equipment under a price adjustment or escalator clause. In a number of states and cities, it has been decided, by the proper legal authorities, that contracts can be awarded with such a clause, provided a definite ceiling is included in the price adjustment. In the territory with which the writer is most familiar, a ceiling of 20 per cent has generally been placed on such items as pumps, boilers and steam turbines, and 10 per cent on pipe valves and fittings. On some items the ceiling has been as high as 30 per cent. These are ceilings for contracts in which the equipment is being purchased directly, and not through a contractor. No trouble has been experienced in getting bids with a ceiling on the price adjustment.

When a contractor bids on work under present conditions, with most of his material and equipment quoted with a price adjustment clause, he will naturally include an allowance for this adjustment in his bid, and it is believed that, generally, the maximum amount is included. Again, as the contractor is unable to forecast accurately what the labor situation will be when the work on which he is asked to bid will actually be under construction, he will, if experienced, try to provide adequate protection in his bid for labor costs that may prevail in the future. It is doubtful whether or not Philadelphia officials know what the failure to allow adjustment clauses in its contracts has cost the city.

For these reasons it seems advisable for the water utility to buy all material directly when it is at all feasible to do so, and so pay only the actual increase in price, if any, rather than the full amount the contractor may have felt he needed for protection of his bid. Also, under such a plan of direct purchase, general construction bids can be called for at a date closer to the time of actual construction, when labor conditions that may exist on the particular job are better known.

That present costs in Philadelphia are approximately 70 per cent above

those existing in 1940 conforms fairly well with the trend in construction costs elsewhere. The author's statement, that one of the causes of increase in cost was the falling off of man-hour performance, is particularly timely. There is ample evidence that the drop in man-hour performance for most tasks connected with construction work is in the magnitude of 50 to 60 per cent and that this drop in production affects costs more than the increases in labor rates.

To water works operators, particularly those operating municipal plants, one feature of the present inflation may deserve mention. Interest rates are much lower than before the war and before the advent of present prices. This is particularly true for municipalities, which are frequently able to finance extensions at from 1 to 2 per cent interest rates. Although the low interest rates constitute one of the most definite indications of inflation, they do make possible the financing of extensions at much higher costs than those of the prewar period, without a corresponding increase in the annual debt service.

It is hoped that what has been said in this discussion, regarding the possibility of decreasing demands, will not be interpreted as meaning that water works operators should discontinue efforts to obtain needed or desired extensions. On the contrary, every effort should be made to obtain plans and specifications for all extensions, and concentrated efforts should be made to accomplish those that are of vital importance as soon as possible. It does seem desirable nationally and advisable locally to postpone all work where such postponement does not endanger the ability to render adequate and proper service. One difficulty, so far as the water works industry is concerned, is that it is unusual for extensions to be proposed until they are needed. The history of most water works systems indicates that needed extensions have been late in arriving rather than otherwise.

Experiences during the war period, however, taught how to forego certain things and also that ingenuity can overcome what at first appear to be impossibilities. The same sort of ingenuity should be applied now, in a period that may find needed water works extensions even more difficult to obtain than they were during the war years.

Chlorination Experiences With Surface Supplies

By S. Jacobson and M. S. Wellington

A contribution to the Journal by S. Jacobson, Chemist, and M. S. Wellington, San. Engr., both of the New Haven Water Co., New Haven, Conn.

THE first chlorinator of the New Haven Water Co. was put into operation at Lake Dawson on January 30, 1914. Chlorine-ammonia treatment was started in 1936 at two of the larger supplies to prevent the development of bacteria in the mains. The results were considered satisfactory from the bacteriological standpoint, although a large percentage of false presumptive tests continued to be obtained, particularly after heavy rains. The chlorine-ammonia process was discontinued in April 1944 in order to obtain the greater bactericidal efficiency of free residual chlorination (1).

Free residual chlorination has been defined as the application of chlorine to water to produce directly, or through the destruction of ammonia, a free available chlorine residual and to maintain that residual through part or all of a water treatment plant or distribution system. This report deals mainly with the company's experiences with free residual chlorination following the application of this form of treatment to all supplies between June and October 1944.

The New Haven Water Co. supplies twelve neighboring Connecticut communities with approximately 33 mgd. of water from ten surface supplies. The water from one of these supplies is filtered through a slow sand filter and the effluent is chlorinated, stored for about an hour, and pumped to the distribution system. The major volume of the water (about 89 per cent) comes from the remaining nine supplies and is either pumped or flows by gravity directly into the distribution system. In three supplies, chlorine is applied at the suction side of pumps by means of manually controlled solution-feed chlorinators. The six gravity supplies are chlorinated by means of automatic venturi-controlled equipment which applies chlorine at a point in the mains near the reservoir intakes.

Laboratory Control

Experimental chlorination studies of all supplies are made in the company laboratory at least twice a year and whenever indicated by unusual conditions. The waters range from a soft, colored water with 26 ppm. color, 17 ppm. hardness, 7 ppm. alkalinity and a pH value of 6.4, to one of moderate hardness and low color, with 12 ppm. color, 53 ppm. hardness, 40 ppm. alkalinity, and a pH of 7.5. For all supplies, the free ammonia nitrogen is less than 0.02 ppm., and the albuminoid ammonia nitrogen is usually less than 0.2 ppm.

The dosages of chlorine are based on the laboratory method described by Griffin (2), using glass-stoppered bot-

tles. In this procedure, the criterion for the required dosage is that it should give a flash residual of free available chlorine equivalent to 85 per cent of the 5-minute residual after the proper contact period with chlorine. For the authors' purposes, a contact period of one hour at room temperature appears to be most satisfactory.

When these studies are made, the taste and odor characteristics are carefully noted by two or more workers. With increasing dosages, the tastes and odors present usually undergo various changes. Low doses either disclose or intensify disagreeable tastes and odors. Higher doses, which produce free available chlorine residuals, give a more or less narrow range of satisfactory water with perhaps a slight chlorinous odor. Still higher doses produce water with a chlorinous odor and metallic taste.

These procedures were of especial value in estimating required chlorinator capacities. The variations in the chlorine dosage have been comparatively small for the large stored supplies. The largest supply, with an available storage capacity of 15,600 mil.gal., has required dosage rates varying from 0.8 to 1.3 ppm., approximately the same as that required by the effluent of the slow sand filter plant. One of the small reservoirs, with a capacity of 20 mil. gal., has required dosage rates varying from 1.4 to 2.2 ppm. The higher rates were used during the late summer and fall.

Treatment Plant Data

Daily records are kept by the treatment plant operators who are supplied with chlorine comparators of the "Hellige" type, reading up to 2 ppm. The flash and 5-minute chlorine residuals are determined after the chlorine has been in contact with the water for 10 minutes. Negligible false residuals have been indicated by the Hallinan test (3). The effects of the average chlorine residuals (5-minute readings) for all ten supplies during the three-year period are shown in Fig. 1.

From January 1943 to May 1944, the chlorine dosage rates were adjusted so that chlorine residuals of about 0.2 ppm. were maintained. Starting in June 1944, some of the supplies were treated by free residual chlorination. Mainly because of insufficient chlorinator capacity, it was not until October 1944 that all the supplies were so treated.

Table 1 shows the average chlorine dosage for 1943 to have been 0.61 ppm., increasing in 1944 to 0.96 ppm. and attaining an average of 1.36 ppm. during 1945. The chlorine residuals averaged 0.23 ppm. during 1943, 0.41 ppm. during 1944 and 0.70 ppm. during 1945.

TABLE 1
Chlorination Data

	1943	1944	1945
Chlorine Consumption, *lb.*	59,625	100,589	143,571
Water Treated, *mil. gal.*	11,846	12,564	12,644
Avg. Chlorine Dose, *ppm.*	0.61	0.96	1.36
Avg. Chlorine Residual, *ppm.*	0.23	0.41	0.70

The practice of free residual chlorination has resulted in a significant increase in chlorine consumption. A total of 59,625 lb. of chlorine was used in 1943, increasing to 100,589 lb. in 1944 and 143,571 lb. in 1945.

Gas-Forming Bacteria

The samples for bacteriological analysis were collected on five days each week from regular sampling points in the distribution system and were rep-

resentative of individual supplies. The sample bottles contained sodium thiosulfate to neutralize the residual chlorine resulting from the higher dosage rates, and the bacteriological tests were made in accordance with the recommendations in *Standard Methods* (4). One of the more evident results of free residual chlorination was the reduction in the number of gas-forming bacteria as shown by the lactose broth tubes of the presumptive test after 48 hours incubation. Although such organisms are usually non-confirming types, their elimination provides an additional factor of safety and indicates a closer approach toward bacteriological purity. Griffin and Chamberlin (5) have described chlorination at filter plants using free residual chlorination and have shown that it was possible to eradicate all late gas-forming bacteria from water without impairment of the taste and odor qualities.

Table 2 shows the overall effect of the increase in the chlorine dosage rates

TABLE 2

Presumptive 10 ml. Tubes Showing Gas in 48 Hours

Year	Average Monthly Percentages: Raw Water	Treated Water
1943	72	43
1944	72	29
1945	67	11

on the annual percentage of 10 ml. lactose broth tubes showing gas. In the untreated water, the average percentage of tubes showing gas during 1943 was 72 per cent, remaining unchanged in 1944 and decreasing to 67 per cent in 1945. In the chlorinated water, however, the average percentage of tubes showing gas in 1943 was 43 per cent, decreasing to 29 per cent in 1944, with further reduction to 11 per cent in 1945.

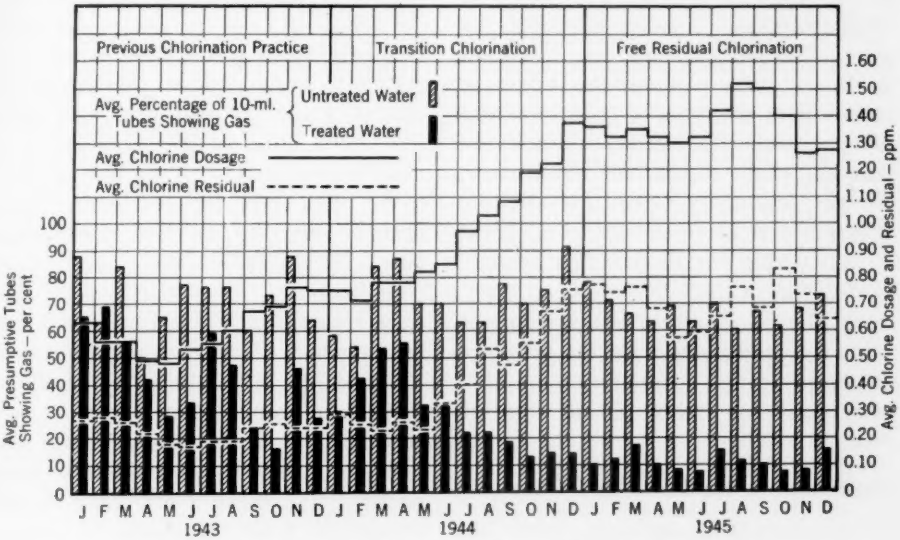

Fig. 1. Chlorination of All New Haven Water Co. Supplies

The monthly percentage of 10-ml. lactose broth tubes showing gas for the treated and untreated waters is shown in Fig. 1. The average percentages of tubes showing gas obtained with the

untreated samples were consistently large during the three-year period, varying from 50 to 91 per cent. Prior to October 1944, the average percentage of tubes showing gas obtained with treated samples varied from 16 to 69 per cent. By comparison, the percentages of gas tubes from the treated samples collected after that date indicate a marked decrease and have remained at generally low values—from 7 to 17 per cent.

Figure 1 is based on averaged data for all supplies. Greater reductions in the percentage of tubes showing gas were observed in some supplies than in others; this is often the effect of variation in the time of contact of the chlorine with the water. When the sampling point is near the chlorinator, the gas producing organisms are less affected than when the sampling point is well within the distribution system. Under the proper conditions of sampling, the presumptive test is of great value for control because the presence or absence of gas formers may be used as a guide or index of the chlorine residual.

Observations on Taste and Odor

Operation at dosage rates lower than those necessary for free residual chlorination will sometimes produce distinctly disagreeable tastes and odors in the distribution system when algae are present. Free residual chlorination has improved the taste and odor of waters containing *Asterionella, Uroglena, Anabaena* or *Dinobryon*. For example, the development of *Asterionella* in a reservoir covered with ice did not produce any undesirable effect. Recent experiences at Maltby No. 1 Reservoir with 10,000 standard units per ml. of *Uroglena,* capable of causing strong fishy tastes and odors, have shown that free residual chlorination was able to produce a marked improvement, especially on prolonged contact. Brush (6) stated that, in certain instances, higher chlorine doses were capable of removing disagreeable tastes due to organisms. In the elimination of the cucumber taste of *Synura,* he also found that an adequate contact period was essential. Less success is obtained, however, with earthy or musty tastes and odors.

The increase in chlorine dosage rates was effected without many complaints despite the number of different supplies involved. It was necessary to flush certain sections where dirty water was present. Pipe deposit decomposition was no great problem, and soon after the introduction of free residual chlorination, residuals varying from a trace to 0.3 ppm. were detected in the distribution system, but not in the dead-ends. For a few months, there were some complaints of chlorinous odors, observed particularly when an outlet was first opened. The first appearance of chlorine in old pipelines, especially of galvanized iron, at times resulted in a short period of undesirable tastes and odors. In general, the number of complaints have been fewer since higher dosage rates were applied.

The experiences on one supply with lime treatment for corrosion control, in conjunction with higher chlorine rates, were unsatisfactory, mainly because of the development of iodine-like tastes. The substitution of sodium hexametaphosphate has resulted in improvement in the quality of this supply.

Conclusions

The New Haven Water Co. obtains its water from surface supplies which are subject to such natural vagaries as seasonal turn-overs, disturbances due to growth of algae, runoff, etc. The

disinfection control measures of the past have resulted in water supplies that have been, for the most part, satisfactory. The application of free residual chlorination has permitted a more scientific method of control, whereby more uniform and improved taste and odor control, as well as bacteriological results, is obtained.

Acknowledgments

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Water Treatment in Connecticut

By Frederick O. A. Almquist

A paper presented on Oct. 17, 1946, at the New England Section Meeting, Boston, Mass., by Frederick O. A. Almquist, Prin. San. Engr., State Dept. of Health, Hartford, Conn.

CONSIDERABLE progress has been made in the addition of chlorine to water since its reputed first use in 1908. Chlorine was then added to water in small amounts to obtain low chlorine residuals, the procedure being known as marginal or normal chlorination. This practice, which continued for a number of years, was superseded by super-chlorination in combination with de-chlorination, then by the use of chlorine with ammonia to form chloramines and, more recently, by high chlorine dosages, without ammonia or de-chlorination, to obtain free chlorine residuals.

Recent Chlorine Uses

At first, chlorine was used for disinfection only, but experience and research have shown other results of benefit to water supply in general. Chlorination has since been used for disinfection, taste and odor control, control of algal growths, bleaching and color reduction, maintenance of pipeline capacities and such improvements in filter operation as result from better floc formation, longer filter runs and the removal of manganese. Most of these applications have been employed in Connecticut, and free residual chlorination is now being practiced by a number of water treatment plants in that state.

Bacteriological Improvement

That there is bacteriological improvement in samples collected in a distribution system after free residual chlorination has been established need hardly be proved at this stage. In an earlier paper by the author (1), results of a number of bacteriological samples collected in the system of the Stamford, Conn., Water Co. were presented. The source of supply is a clean watershed and dependence for safety is placed on chlorination alone. Free residual chlorination was initiated on December 29, 1943, and carried on for one year, to December 28, 1944. It was discontinued temporarily because of inadequacy of pumping equipment in the operation of the chlorinator. By the end of the year, chlorine residuals were just appearing at the ends of the system. Normal chlorination was carried on until July 18, 1945, when the rate of chlorine dosage was again increased, and on August 2 free residual chlorination was again begun and has been carried on to the present date. Table 1 shows the results of bacteriological examinations made on samples of water before and after free residual chlorination. The results in 1943 and for 1946 to April 30 should be compared to note the real effect of free residual chlorination, although a tremendous improvement was noted

in 1944, the first year it was used. The procedure of Standard Methods (2) was followed in the analysis of the samples in Table 1. This excellent improvement in bacteriological results parallels that observed on other water supplies.

Tastes and Odors

Experts tell us that tastes and odors are very closely allied and that often what is thought to be taste is in reality odor. There does, however, appear to be a distinction which is noticeable in sampling water. In this connection, it appears that free chlorine in many waters causes no taste, but that chloramines do. As chlorine is added to water containing organic matter and some ammoniacal products, as most New England surface waters do, a reaction occurs and the materials are oxidized. As more chlorine is added, free chlorine appears, and when orthotolidine is added, the immediate or "flash" color that is characteristic of free chlorine appears. The chloramines react more slowly with the ortho-tolidine and the color develops more slowly. When a flash test is obtained which does not increase in 5 minutes, it is usually assumed that the total reading is free chlorine and no chloramine exists. At this point of full free residual chlorination, the taste in most waters seems to disappear.

It has been found generally that, although the taste seems to disappear, there is a momentary odor of chlorine as the water leaves the tap. Some objection has been noted from consumers because of this momentary odor but it usually disappears very quickly and, on the whole, the over-all improvement in taste and odor conditions effected by free residual chlorination has been noticeable and favorable.

TABLE 1

Bacteriological Results at Stamford

	1943	1944*	1945 (to July 31)	1945* (from Aug. 1)	1946* (to Apr. 30)
Samples Examined	20	131	75	52	39
No. of 10-ml. Tubes	100	655	375	265	195
Tubes Showing Lactose-Fermenting Organisms	69	55	50	60	4
Tubes Showing Lactose-Fermenting Organisms, %	69	8.4	13.3	23	2.1
Tubes Showing Coliform Organisms	7	11	8	5	0
Tubes Showing Coliform Organisms, %	7	1.7	2.1	1.9	0

* Free residual chlorination in effect.

As high chlorine residuals enter a distribution system, chloramines are formed with materials in the pipelines until the material is removed either physically by sloughing off or by chemical reaction. A border or band where chloramines are formed therefore penetrates into the distribution system, moving fanshape to the outer ends. Within this band, tastes and odors are encountered and frequently coliform organisms as well, despite the high chlorine dosages at the source.

Sometimes tastes and odors are found which high chlorine dosages will not eliminate. It has been evident from field studies that free residual chlorination is not a panacea for all taste and odor conditions.

Influence of pH

Jacobson and Wellington of New Haven (3) report that the addition of lime to obtain high pH values for anti-corrosion treatment does not work well with high chlorine dosages. A noticeable medicinal or iodoform taste results which is very objectionable. It is also a known fact that, with high pH values, the bactericidal effect of chlorine is adversely affected. If it is desirable to add lime, it should be added after the chlorine, allowing enough contact time for the chlorine to destroy any harmful or objectionable bacteria that might be present.

On one unfiltered surface water supply where super-chlorination and de-chlorination with sodium bisulfite were practiced, the treatment was changed to free residual chlorination. Although chlorinous odors are still experienced, there has apparently been an over-all improvement in taste and odor conditions, as the number of complaints has decreased considerably. There has also been a definite improvement in bacteriological conditions, as a chlorine residual is now found practically throughout the distribution system.

Control of Algae

Copper sulfate is still the best chemical to use for destroying algal growths in a reservoir. It is not always feasible to apply it, however, particularly when a thick ice is present. On several occasions, when algal conditions were experienced in a reservoir and copper sulfate could not easily be applied, it has been reported that high chlorine dosages had eliminated complaints of tastes and odors.

Chlorine Dioxide

In discussing the elimination of tastes and odors in a water supply, attention should be called to the use of chlorine dioxide. This treatment, so far as the writer knows, was first tried at Niagara Falls, N.Y. Experiences and experiments with this process were described by McCarthy (4) in May, 1945. McCarthy concluded that treatment of water supplies with chlorine dioxide can result in satisfactory removal of tastes and odors and stated that disinfection must be separated from odor treatment. The disinfection should generally be completed before the application of dioxide; otherwise very high residuals must be carried. As yet, chlorine dioxide is not used on public water supplies in Connecticut.

Chlorination at Filtration Plants

As noted elsewhere, chlorination is used in many ways to aid filtration. These methods include pre-chlorination, manganese removal, post-chlorination and chloramination.

Pre-chlorination

Pre-chlorination on water in filtration plants has been reported to be beneficial for a number of years. Benefits accruing from such treatment are improved bacteriological results, improved floc formation when alum is used, longer filter runs, improvement in odor conditions in the sedimentation basin and better conditions in the filter, resulting in cleaner sand. Although pre-chlorination experience in

Connecticut is somewhat limited, the claims made for it appear to be warranted under most normal conditions.

When pre-chlorination is used so that chlorine is carried up to the filters, close observation should be exercised to see that the filters do not unload and cause turbidities in the treated water, and also to assure that tastes and odors are not obtained from the formation of chloramines and chlorine products in the filter. Chlorine should preferably be applied slowly and the amounts gradually increased. Until a chlorine residual appears in the filter effluent, post-chlorination should be maintained.

At two filtration plants in Connecticut where the water is chlorinated before it enters the filtration plant, the bacteriological results have been good enough so that post-chlorination might not be necessary. Post-chlorination, however, is maintained for additional safety. The chlorine residual of the incoming water varies from about 0.05 ppm. to 0.20 ppm. after perhaps a ½-hour contact period. This means that no chlorine residual is found on the filters at these plants. Post-chlorination is used with low chlorine residuals, usually less than 0.15 ppm. One plant uses chlorine in conjunction with ammonia. Excellent bacteriological results are found, and organisms of the coliform group are rarely isolated.

Two plants have reported gratifying results when pre-chlorination was used, chlorine being added in the mixing basin to give a free residual. Quicker and better "floc" formation was obtained with alum, especially during times when water temperatures were low. During the winter season, when there is likely to be some difficulty with "floc" formation if alum is used, every possible aid should be enlisted.

Within the last month, the author's attention was called to increased filter runs at one plant when free residual chlorination was introduced before filtration. The rate of dosage was such that a chlorine residual of from 0.15 to 0.20 ppm. was found on top of the filters, with no residual after filtration. There was 80 ppm. of color in the untreated water; 21.4 ppm. of alum was added; and the rate of chlorine dosage was 25 lb. per mil.gal., or 3 ppm. The filter runs were almost immediately increased from 12–14 hours to about 30 hours.

Although the sedimentation basin at this plant is cleaned every two or three months, the odor was very objectionable when the manhole cover was removed, and was definitely noticeable for some distance downstream when the basin was cleaned and the sludge discharged to the stream. Since a rate of pre-chlorination that would establish a free residual has been used, however, the odor has almost entirely disappeared.

Removal of Manganese

Removal of manganese through the use of high-rate pre-chlorination at a filtration plant has not been tried, as such, in Connecticut. Success in removal of manganese by this method at Montebello Filters, Baltimore, Md., has been reported by Edwards and McCall (5). Previously, at periods of the year when the manganese content of the raw water was very high, it was necessary at this plant to change coagulants from alum to ferrous sulfate and lime, in order to maintain the required high pH values. When free residual chlorination was used before

filtration, however, the oxidation and contact in the filters was sufficient to remove all the manganese. The chemical cost of this method at Baltimore was less than the cost of the older method.

Post-chlorination

At one plant where pre-chlorination is used, post-chlorination to the establishment of a free residual is also practiced. Odors, otherwise difficult to remove in the ordinary treatment in connection with filtration, are considerably lessened, although not eliminated, by carrying a chlorine residual through the distribution system. The most noticeable results, however, are bacteriological. An uncovered standpipe rides on the system and, when normal post-chlorination was practiced, organisms of the coliform group were occasionally found in samples collected for analysis in the distribution system. Since free residual chlorination after filtration has been established in the system, no organisms of the coliform group have been isolated.

Chloramination

Chloramination is now used after filtration in only two treatment plants in Connecticut. At one of these plants, the untreated water is chlorinated some distance above the plant. In both plants, bacteriological analyses have been excellent, as might be expected with a chloramine residual in the distribution system. Although the bactericidal action of chloramines is much slower than that of chlorine alone, chloramination is feasible when a clear water basin is available to provide the necessary contact period. A 30-minute contact period should be considered as a minimum, although a 2-hour contact period is preferable. Usually abnormal tastes and odors can be eliminated at the filtration plant, making the chloramine treatment serve primarily for disinfection.

Free Residual Chlorination Practice

When free residual chlorination is begun, abnormal tastes and odors will undoubtedly be obtained in the distribution system until the organic matter in the system has been oxidized or dissipated and free available chlorine established. The length of time that these conditions persist will depend very much on the condition of the distribution system. Material will probably be loosened from the piping interior, and the rate of chlorine dosage should, therefore, be increased slowly, perhaps over a period of two or three months or even longer. Flushing may be necessary and helpful.

Many water plants using surface supplies unconsciously practice free residual chlorination during the winter season when the organic content is low, and normal chlorination results in free chlorine being carried well into the distribution system. At these times the disturbance seems to be at a minimum, and it would therefore seem a logical time to begin planned free residual chlorination if it is desired. It is also at this time that algal growths are usually at a minimum, and complications from this source will not be encountered.

Determination of Rate of Dosage

It should be recognized that every water supply presents a different problem. Some care should be exercised in establishing the rate of chlorine dosage and fairly close observations should

be made on the water after varying periods of contact. Jar tests described by A. E. Griffin (6) are helpful in arriving at a proper dosage.

Survey of Equipment

The use of free residual chlorination under most conditions, especially on unfiltered waters, requires a rather sharp increase in the rate of dosage of chlorine. It may have to be an increase of from 1 ppm. to 4 or 5 ppm., and sometimes even more is required. Another argument for the use of jar tests, at least in the beginning, is that some idea can be obtained of the amount of chlorine that might be used. Often the capacity of either the chlorinator or its associated equipment may not be sufficient to meet the requirements. It is desirable to obtain a free residual or not to attempt high-rate chlorination at all, as continuous chlorination with high dosages that do not establish a residual may result in objectionable conditions. Tastes and odors objectionable enough to cause complaint have been found when a free residual was not quite reached. Medicinal tastes and odors were found on an unfiltered supply when the chlorine residual was reduced from 0.65 ppm. to 0.45 ppm., resulting in a small increase in chloramines. The equipment should, therefore, be thoroughly surveyed, probably with a representative of the manufacturer, to make sure that sufficient machine and pump capacity is available.

In the survey, it would also be desirable to determine whether there is sufficient storage and handling capacity for the chlorine supplies. This would be particularly applicable for large supplies, for which ton containers of chlorine might possibly be used to reduce the cost of the increased chlorine use.

Chlorine Contact

The period of contact between chlorine and water is very important. Observations made in the field have shown that after free residual chlorination has been established, abnormal tastes and odors were found as far as two or three miles from the point of chlorination, whereas the taste and odor had disappeared at twice this distance. There was no question but that the added time of contact improved the physical characteristics of the water.

High Chlorine Dosages

There is a considerable advantage in using high chlorine dosages if there is a possibility of quick changes in the chlorine demand. These changes can be caused by algal growths in a reservoir, a quick run-off with a relatively small storage, a change in the direction of the wind, reservoir overturns and other factors. When low chlorine residuals are used, a sudden increase in demand may decrease the chlorine residual or completely eliminate it, leaving an under-chlorinated water and an opportunity for undesirable bacteria to enter the distribution system. Studies of three distribution systems in Connecticut reported by W. J. Scott (7) have shown that when these organisms reach the distribution system, they may persist for long periods unless a chlorine residual penetrates the system to destroy them. Samples of water collected for examination may be poor bacteriologically even though normal chlorination is restored and maintained at the chlorinator installation. High chlorine residuals, on the other hand, would be less affected by sudden increases in demand, and in all likelihood enough residual would remain to destroy harmful types of bac-

teria that might be present. If chlorine residuals are maintained in the distribution system, samples collected for analysis should probably be collected with sodium thiosulfate.

Some reduction in the physical color of water has been reported through the use of high chlorine dosages. A slight indication of this has been noticeable on one or two supplies in Connecticut but no very pronounced color reductions have been recorded.

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Water Treatment in Maine

By J. Elliott Hale

A paper presented on Oct. 16, 1946, at the New England Section Meeting, Boston, Mass., by J. Elliott Hale, Tech. Secy., San. Water Board, Augusta, Me.

WATER treatment problems in Maine are no different from those experienced in the other New England states. There are the same difficulties with color, turbidity and odor and even a few problems created by the discharge of industrial and sewage wastes into the raw water supply.

At present there are 162 public water utilities in the state that serve approximately 550,000 persons, or about 68 per cent of the total state population. Ninety-seven of these utilities secure their water from surface supplies, and the rest employ wells or springs.

The necessity of establishing water treatment plants has been brought about because of several undesirable elements in the raw water: color, turbidity, iron, odors and industrial and sewage wastes.

These utilities have constructed 22 water treatment plants. Five plants are in operation for treating waters that are polluted by industrial and sewage wastes, two for the removal of natural iron and the rest for the removal of color, turbidity or odors.

The treatment plants at South Berwick and Sanford remove natural iron present in the ground water by aeration and rapid sand or pressure filters. A reduction in the iron content from 2.5 or 3 ppm. in the raw water to about 0.1 ppm. or less is thus accomplished.

At the majority of the treatment plants, color, turbidity and odor are the main problems. The surface supplies, consisting of streams, ponds and rivers, are subjected to natural forces which produce these objectionable features in the raw water. In some plants, it is a high color that has to be removed; in others, the turbidity of the stream or brook changes with every rainstorm, and, in still others, the varying loads of industrial and sanitary wastes, together with color and turbidity, make the prospect a continually changing one.

At Presque Isle, water treatment men have been confronted with the problem of removing from the raw water a highly disagreeable odor caused by the fermentation of starch wastes which are being discharged into the water supply about five miles upstream from the treatment plant. During periods of normal rainfall and operation of the factory, the effect of the starch wastes upon the raw water does not seem to be noticeable, as the filter plant was apparently designed to treat such waters, but under abnormal conditions of low stream flow and unseasonable operation of the factory, the condition of the raw water is such that the present treatment plant is of little use. Combinations of high chlorine and ammonia dosages, activated carbon, alum, lime, flocculation, coagulation and rapid sand filters and even

chlorine dioxide have failed to remove enough of the odor to make the water even barely palatable. The problem still exists, as no practicable solution has been found. The most logical solution is to remove the starch wastes from the stream above the filter plant. To this end, research has been undertaken that should find a logical and economical solution for this problem.

At Bangor a water that has been polluted by industrial wastes, mostly from paper mills, and by sewage wastes from several towns and cities, must be treated. The stream flow is also variable and adds to the problem. About 4 mil.gal. are filtered daily, using prechlorination, alum, lime, aeration, carbon, sedimentation, rapid sand filters, chlorine dioxide, lime and post-chlorination. With this treatment the color is reduced from an average of 55 ppm. in the raw water to 10 ppm. in the effluent. Positive samples of *Esch. Coli* are reduced from 90 per cent to about 0.058 per cent of the 10-ml. portions, but the water still has a distinctive odor, produced apparently by the complexity of the raw water and by the various chemicals used in the treatment process. A real solution for proper treatment of this water has not been found. At present the water department is making a survey and study of a possible surface supply that will be adequate and satisfactory.

One of the most modern treatment plants in the state is that of the Biddeford and Saco Water Co. Several years ago this plant was thoroughly modernized and it seems to be doing a fine job. A modern plant with complete treatment is necessary because the Saco River, the source of the raw water, has a varying stream flow. Considerable color and turbidity and some algae, therefore, are experienced. The treatment consists of: (1) prechlorination, (2) coagulation with alum and lime, (3) settling, (4) rapid sand filtration, (5) pH control with lime, (6) stabilization with sodium hexametaphosphate and (7) sterilization with chlorine and ammonia. The color is reduced about 80 per cent, the pH raised from 6.4 to 8.0 and the turbidity reduced from 5 or 10 ppm. to 0. There is also complete removal of the bacteria from the raw water.

Several years ago the Portland Water Dist. experimented with a so-called magnetite filter for the removal of algae. Apparently it was not the type of filter that could readily be adapted to the needs of the district because of the large amount of water that had to be filtered daily. Several new ideas have been advanced and the district is studying them, hoping that one of them will be the solution to its problem.

The other treatment plants are of small size and do not use complete treatment, yet they seem to serve in their way to correct conditions in the raw water that would otherwise make it objectionable for domestic use. Many of the plants appear outmoded in the light of some of the modern practices, and it will be necessary to modernize them completely in order to satisfy the demands now being made by the public for a safe and palatable drinking water.

Even though considerable progress has been made by other states in the development of very efficient plants, it will be a long time before many of the present treatment plants have overcome the present inertia to make it possible to produce a final effluent that tastes like good drinking water.

Water Treatment in Massachusetts

By Joseph A. McCarthy

A paper presented on Oct. 17, 1946, at the New England Section Meeting, Boston, Mass., by Joseph A. McCarthy, Chief of Lab., State Dept. of Public Health, Lawrence Experiment Station, Lawrence, Mass.

MASSACHUSETTS has what may appear to be an astonishingly small number of treatment plants in comparison with other states. Of the approximately 420 supplies, ranging in size from one furnishing three or four families with water to the Boston Metropolitan Dist. Supply, serving more than half the population of the state, only 26 are provided with filter plants intended primarily for purification and only 12 with iron-removal plants. This situation results directly from the fact that the majority of the systems, including such large ones as that of the Boston Metropolitan Dist., have been able to obtain sufficient volumes of surface water of a good enough quality to render a safe and potable effluent after storage in either natural lakes and ponds or in artificial impounding reservoirs.

The Boston supply is impounded in the Quabbin Reservoir system and fed through Wachusett Dam to the metropolitan area. Similarly, other urban areas, with a population of nearly a million and a quarter, rely on impounded supplies to serve their own consumers and those of neighboring communities of populations totaling another 50,000.

Virtually every supply in the state, whether filtered or not, is chlorinated. It is the policy of the Dept. of Public Health to maintain, wherever possible, regular sampling of stored or filtered water before final chlorination, thus making available a good picture of the degree of purification obtained by preliminary treatment.

Some of the stored waters are originally fairly high in bacterial content, but, if the period of storage is sufficient and the reservoir is properly protected, the bacteria are very materially reduced in numbers. Raw Quabbin water is quite low in bacteria, and the long period of storage gives decided improvement. When the proposed changes in the conduit system, which will eliminate all open channels, are completed, it can be expected that the bacterial quality of Quabbin water as delivered to the distribution stations in metropolitan Boston will be well below the U. S. Public Health Service standard of 1 M.P.N.

One very important feature in maintaining the purity of a stored supply is the degree of protection given the reservoir, a protection best obtained, of course, by complete ownership or control of the lands surrounding the stored water. Many cities and towns years ago built reservoirs which seemed to be so far from built-up areas that no possible danger of contamination could arise; but too often new housing developments sprang up before the water

authorities could or would protect the water storage. A large part of the land surrounding the reservoir of one small supply lay in a neighboring town, and this complication delayed the purchase of land essential for safety. Quite suddenly, the town found a large housing development and a summer resort too close to its water supply for comfort, and the utilization of a nearby bog for cranberry culture further added to the difficulties. The water, once practically free from coliform organisms, began to show considerable concentrations of them, so that filtration or abandonment of the source now seems inevitable. Distributing reservoirs in two cities, isolated a few years ago, gradually became surrounded by housing developments, and the quality of the water suffered. In one city war gardens near a distributing reservoir had received fertilizer of an animal origin, and a dry month, with wind steadily blowing toward the reservoir, resulted in an immediate appearance of coliform bacteria, necessitating prolonged surface chlorination for several weeks. This incident of course would not warrant condemnation of a supply, but it does serve to indicate the necessity for constant watchfulness.

On the other hand, one medium size city, after many years of negotiation, succeeded in purchasing an icepond which drained into one of the city reservoirs. A high bacterial count had been found each year after ice-cutting operations, with coliform organisms present for several years in 0.1 ml. in samples near the icepond. In the first year after ice-cutting had been suspended, none of the Spring samples showed coliform organisms in 1 ml., and in the following years nearly all of the 10 ml. portions were negative. Striking results were also obtained by a somewhat larger city when, as a result of wartime precautions, its watershed was completely closed. The average plate counts in 1943–45 were only about 20 per cent as high as in the 3 years before the war, and the coliform organisms practically disappeared.

To investigate the effects of storage upon surface waters, an experiment has been carried on for many years at the Lawrence Experiment Station of the Dept. of Public Health, in which the highly polluted Merrimack River water is passed through a series of baffled tanks at such a rate as to give an overall storage of 30 days. The stored water shows quite considerable reductions in suspended solids, iron and organic matter, but the removal of bacteria is even more satisfactory. In the 5 years from 1941 through 1945, the bacteria were reduced from 37,000 to 280 per ml. at 20° C., or 99.2 per cent. Many samples of the stored water are completely free of coliform organisms, and the 5-year average shows a content of 31 per 100 ml., compared to 3,900 in the raw water, a reduction, also, of 99.2 per cent.

Slow Sand Filters

Most of the slow sand filters in the state are fairly old. At a great many of these plants, the original operators had grown old along with the plants, and the invaluable experience they had acquired resulted in the production of water of excellent quality, especially from the standpoint of bacterial content. It seems only natural that the obtaining of such excellent results, with an apparent minimum of difficulty, should have led to a feeling that the operation of slow sand filters would go on forever, automatically producing water of high quality.

Wartime conditions, however, began to disrupt the carefully built up and highly trained crews which had handled these filters so well. Especially when, as happened several times, the key man, for one reason or another, left his job, it soon became evident that the slow filter was sensitive to interruptions in the almost loving care to which it had become accustomed. New and often smaller teams found that operations, such as scraping and resanding, which had once proceeded easily, with no interference in production or in quality, now presented unexpected difficulties.

The placing of new sand to restore units to their original depth gave more than one problem. The attention of the department was called to one slow filter, in which investigation showed that the addition of new sand markedly different from the old, especially in calcium and magnesium content, had resulted in highly irregular stratification, which naturally caused a certain degree of short-circuiting. The variations in velocity were self-magnifying, and the degree of purification began to decline rapidly, with increases in color and iron and rather violent changes in pH, accompanied by higher bacterial content, thus throwing a load much greater than normal on the final chlorination, Fortunately, the coliform content of the raw water was never great, and the finished water always remained within the standard. Careful replacement of sand very soon restored the filter to normal.

At one or two supplies, increased demands led to attempts to operate filters at rates much higher than normal. One filter thus operated for a short time turned out larger volumes of water with surprisingly small deterioration in bacterial quality, but more and more frequent surface clogging soon developed, and thus, as with all of those slow filters on which rates were increased, a return was forced to more reasonable operation. In none of these instances was there found any serious reduction in bacterial quality, since the filter always responded to ill treatment by clogging. On the whole, and especially from the bacterial standpoint, the slow sand filters made a splendid showing during the difficult war years. It is interesting to note that the 12 iron removal plants, practically all of which include filtration, have all continued to give excellent bacterial quality. A hasty glance through the department records shows an almost complete absence of coliform organism in the last 300 samples from these plants, and generally very low plate counts.

Rapid Filters

There are 11 rapid filter plants in the state, and nearly all of them have their own interesting peculiarities. Most of them treat water from storage reservoirs, and the bacterial content of these waters after storage is generally quite good, leaving as the main work of the filters the removal of color and other organic matter.

Athol uses a 1-mgd. filter to treat the water from two or three storage reservoirs, one of which contributes a supply which, even after storage, frequently has a color content of 150 ppm., many bacterial organisms and a very low pH value. Yet the two small filters produce a very satisfactory effluent which is free from taste, low in color and bacteria and entirely free from coliform organisms even before chlorination. The plant is unique in that "Blackalum" has been used ever since the filters were first put into operation.

The cities of Beverly and Salem together operate a modern 6-mgd. plant filtering water stored in Wenham Lake. The natural yield of the watershed is augmented by pumping flood water each spring from the Ipswich River. This results almost every year in a tremendous growth of diatoms and algae, but bacteria, especially of the coliform group, are decidedly low in number, and, although filter runs drop to 6 and 8 hours, coliform organisms are practically never found in the filtered water.

The Braintree and Randolph-Holbrook filters obtain water from opposite sides of a natural reservoir, high in color and organic matter from swampy tributaries and heavy growths of deciduous trees in the watershed. It has been interesting to observe how much difference in optimum chemical dosage has been shown at various times between the two plants, apparently largely as a result of prevailing winds causing differences in the development of overturns. The filtered waters from both plants have been very satisfactory bacterially, even though the raw water has had, at times, a fairly high bacterial content.

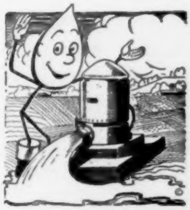
The small plant at Rockport is unusual in that it treats two distinctly different raw waters, one a colored soft surface water, and the other a relatively hard ground supply. It is often necessary to change quite abruptly from one to the other, with, as might be expected, considerable adjustments in coagulation and upsets in the filter, at times requiring almost gymnastic agility in operation. This filter, however, also produces water that is always excellent bacterially.

The raw water treated in Chicopee's 6-mgd. plant comes from a rather long narrow reservoir in a watershed on which there are tremendous numbers of deciduous trees, mostly scrub oak. For many years the high color and organisms in the stored water, together with an unusually short sedimentation period in the plant, have offered a difficult problem. Coliform organisms in the filtered water have been quite few, but other bacteria, especially several types of chromogens, have been too plentiful. Even after chlorination sufficient to remove coliform bacteria completely, plate counts on samples from the distribution systems were often distressingly high. During the early part of the war, an airfield was established near the reservoir, and oily drainage still further complicated the taste and odor problem and also affected the chlorination results. Eventually chlorine dioxide treatment was tried. The observations on the effect of this chemical on tastes and odors at Chicopee and elsewhere have been that, although the chemical is by no means a panacea, on certain waters, under proper control, it does reduce various kinds of tastes and odors. As a bactericide, it is efficient in waters very low in organic matter. At Chicopee it proved to be an effective vehicle for active chlorine, and the reduction in plate counts throughout the system was and has continued to be marked.

From the bacteriologist's view, Lawrence is the most interesting of the Massachusetts filter plants. The raw water, taken from the Merrimack River, is very low in alkalinity and turbidity, fairly low in color and organic matter and iron, but extremely high in bacteria, with the coliform content occasionally approaching one million per 100 ml. The low turbidity and alkalinity make good floc formation difficult, but thorough mixing,

long sedimentation and triple application of chlorine produce a finished water which in 1945 showed no coliform organisms in 2,000 fermentation tubes.

Very few supplies have shown samples with any significant number of coliform bacteria in late years, but more and more samples, especially from good filters or efficient storage systems, followed by effective chlorination, have shown vigorous 48-hour fermentation in the lactose tubes. Metropolitan Boston water, coming from the reservoir with the longest storage period, and Lawrence water, with its excellent coliform record, for long periods showed practically 100 per cent fermentation in all of the tubes. A careful study was made, and it was found that the synergistic action of two and sometimes three different bacteria is responsible for these fermentations. One of these is very difficult to isolate, but once cultures were obtained, it was possible to produce great quantities of gas by several different combinations. At least 10 ppm. of chlorine was found necessary to prevent this formation of gas. So far no sanitary significance has been attached to this, but, if some such significance should eventuate, present treatment methods would have to be changed radically. Barring such an upset, the author believes that water treatment on the whole is highly effective in Massachusetts, according to present standards, and special investigation on a few typical supplies indicates that, if necessary, much more rigorous standards can be met in the future.



Water Treatment in New Hampshire

By Leonard W. Trager

A paper presented on Oct. 17, 1946, at the New England Section Meeting, Boston, Mass., by Leonard W. Trager, Director, Div. of San. Eng., State Dept. of Health, Concord, N.H.

In New Hampshire, more than 50 per cent of the water supplies are derived from surface sources. This amount is to be expected in a state with so many lakes and such topography. Most surface supplies are taken from uninhabited areas, but this fact alone does not produce excellent bacteriological results. The regulatory powers over sources of supply which the state has had for many years have made possible the elimination of most supplies which have afforded poor analytical results. All newly proposed supplies must receive state approval, and there is enforced a policy of selecting only the sources having good or excellent physical and chemical characteristics. This selectivity, combined with favorable geological, topographical and climatic conditions, has made necessary very few water treatment plants in the state.

Contamination of Watersheds

Of course, even such favorable watershed conditions do not eliminate contamination altogether. Poor bacteriological analyses are often encountered, even in supplies from watersheds that are normally uninhabited. Lumbering operations are heavy offenders, yet it is not always known when they are to begin on lands not owned by the water departments. A number of times in the past few months, excessive contamination in the water samples submitted for analysis was traced to lumbering and lumber camps, and surveys showed that the horses contributed most of the pollution material on the watersheds. Once over 10 cu.yd. of manure was found not more than 10 ft. from the stream.

As a result of this increase of lumbering troubles, a series of regulations have been submitted to the Board of Health. If these regulations are passed, it will be mandatory for lumber operators to notify the board before any operation can start. In addition, the regulation specifies that no horses can be used except by special approval of the board, and rules concerning toilets, sink drains and other sanitary facilities are included.

The greatest trouble on surface water supplies, however, is caused by the presence of wild animals. With an abundance of deer and fish (particularly trout), hunting and fishing, as well as mountain climbing, are to be expected. The amount of contamination contributed by the hunter, fisherman and hiker is small compared to the contamination contributed by the animals, but it is of the type that is most dangerous.

The one wild animal that causes more trouble than all the rest is the beaver. These creatures, found in all sections

of the state, are numerous enough to have invaded the watershed areas of many public water supplies. The trouble that is caused, of course, is not only that represented by the poor physical quality of the water but also by the heavy bacteriological load. Strangely, the beaver is so equipped that he can relieve himself only when in the water. This means that all fecal matter from a beaver is deposited in the water, heavily contaminating it. Trapping the beaver on the watershed is only a temporary expedient, because these animals travel great distances and, if they find a place to their liking, they will surely return. Killing all the beaver is not allowed by the game protective laws.

Chlorinator Installation

To correct such poor bacteriological results as periodically occur, the Dept. of Health advises and orders the installation of chlorinators. This corrective measure may appear simple, but experience has shown it to be otherwise.

From 1912, when the first chlorination plant was installed in the state, until the early 1930's, a high percentage of the pumped supplies were provided with chlorinators. These were rather simple installations, mechanically, employing a constant-rate, gas-type apparatus, and they provided the protection demanded. It was the towns and villages which were supplied through gravity variable-flow systems, on which chlorination could not be resorted to, that gave health officials their greatest concern during those years. Finally, in the early 1930's, a new manufacturer produced a hypochlorinator which, it was felt, would give the complete protection demanded for small gravity, variable-flow systems. These machines and others subsequently developed are directly connected to standard water meters. In this way, chlorine is supposed to be applied to the water in proportion to the changes in rate of water flow.

In all fairness it must be said that these hydraulically operated chlorinators have, for the most part, given excellent service and have provided the protection demanded. They cannot, however, exceed their designed capacities. They must be installed with meters that will not only provide proper chlorination for the average flow but for maximum and minimum flows as well. In order to meet these requirements, one must take into account all the various circumstances and conditions likely to arise in the system being equipped. The variables encountered may be complicated by a set of circumstances somewhat as follows:

1. The population of only 200–300 in winter may jump in the summer to 3,000–4,000.

2. There may be a single source of supply, but quite often there are two or three, all derived from small streams.

3. If several gravity sources are used, the small intake reservoirs may be at different elevations, at times causing conditions of no flow at all, and at other times causing heavy flow through the pipelines.

4. A similar condition may occur if an auxiliary pumped supply is turned on to augment the brook systems during some of the dry seasons.

5. Coincident with the increased summer population, with its subsequent demand for more water, there may be seasonal industry, which would demand relatively large quantities.

6. Due to the large summer population, there may be a relatively high property valuation and, therefore, ade-

quate fire flow for protection of the hotels would be demanded.

In New Hampshire no single system encounters all of these conditions. There are, however, a number of systems in which two, three and as many as five of them exist.

At times the total consumption of some supplies, including leakage, is less than 10 gpm. The maximum fire flow demand for several of these systems, however, is in excess of 2,000 gpm. It can be seen, therefore, that a Venturi meter which has a registration ratio of only 10 to 1, or at best 15 to 1, would not meet the requirements of such communities. Similarly, it can be seen that no straight-line current or disc meter would meet these requirements. It has frequently been found that the only meter which would register and provide adequate chlorination in these wide ranges is the so-called fire flow or detector meter.

When the fire flow meter is used, two hypochlorite injectors are needed—one on the small bypass line and one on the main line. It has often been found that the small bypass meter will take care of the total consumption on most days, allowing the detector check to open only rarely. If this secondary chlorinator is allowed to develop leaks or is not kept in excellent working condition, therefore, the machine is likely to lose its prime and, when this happens, the high flows will go through without any chlorine being added.

Since only about 30 per cent of the gravity variable-flow water systems are provided with automatic chlorinators, and since about 40 per cent of the water systems in the state are gravity supplies, it can be seen that the efforts of the state health engineers to obtain installation of chlorinators are an important and time-consuming part of their job. At the time of this writing, five chlorinators are being installed, installation orders have been issued to four other supplies and discussions are being held on the subject with two more.

Forest Management for Newark

By John M. Heilman

A paper presented on November 8, 1946, at the New Jersey Section Meeting, Atlantic City, N. J., by J. M. Heilman, Forester, Newark Div. of Water, Newfoundland, N. J.

THE Pequannock Watershed of the city of Newark is situated in parts of Passaic, Morris and Sussex counties in New Jersey, and consists of a single catchment basin of 63.7 square miles. The city of Newark owns approximately 86 per cent of the land, or about 35,000 acres.

Certain reservoirs and parts of this acreage were sold to the city in the late 1890's and early 1900's by a private company which, for a period of years prior to the sale, had been selling water to the city. The city increased its holdings of watershed acreage very materially from the original purchase up to about 1928.

Purchase of the watershed land has been for the purpose of obtaining natural water without the expense and costly treatment necessary with filtration. As farms were purchased and barns and homes torn down, the material which could be salvaged was transported off the drainage area and used to construct new homes for the watershed labor at a site named New City.

Today the watershed is inhabited by about 1,500 permanent residents. It is believed less expensive to service these watershed homes than to buy the remainder of the property, for the same condition exists here as elsewhere when land acquisition has taken place—a large proportion of the land in a section may be obtained at a fair price, but there are always a number who are so attached to their homes that an unreasonable evaluation results.

This watershed of about 64 square miles contains reservoirs with a total available storage capacity of about 10.5 bil.gal. The great bulk of the work on it is not forestry, but consists of general maintenance, such as stream cleaning, refuse collection, policing and other sanitary measures. While these functions require most of the watershed organization, they are not the subject of this discussion.

Forest History

Forestry on the watershed began in the first decade of the present century. According to the older watershed laborers, the first plantings were of Scotch and Austrian pine, made in 1906 with seed imported from abroad and raised in a small nursery near the present headquarters. About 1910 the planting stock itself was imported from abroad because the losses in the nursery were excessive, and there were as yet no forest nurseries in this country.

These early plantings were made at a time when there were no more than three forest schools in the United States and the faculties for these

schools were generally trained in Europe. They were therefore made according to European methods, with spacing of the planted trees about 3 by 3 ft., or four times as close as the present standard practice of 6 by 6 ft. spacing. In Europe this close spacing was justified because branches the size of a lead pencil could be marketed at a profit, but in the United States economic conditions were entirely different. The stands could not be profitably thinned out at regular intervals, and the result was that many of them stagnated. These early plantings, however, pointed the way to the better stands of today, so that now one stand on the Pequannock Watershed is periodically measured by the state as a basis for yield tables, and some small dimension lumber has been cut from other stands for watershed use.

This first phase of forestry on the watershed continued until about 1932 and may be summarized briefly:

1. A total of about 300 acres of trees were planted, with good survival. About 80 per cent of the planting was in conifers; the balance was in hardwoods such as walnut, ash and oak.

2. Other forestry work consisted principally of selling dead chestnut, a few intermittent sales of live timber and protection of the area from fire.

Late in 1931, a resident forester was placed on the watershed and, with the relief labor present at that time and the Civilian Conservation Corps which followed, a great deal was accomplished that would otherwise have required very many years.

Forest Policy

The forest policy on the watershed begins with the simple principle that the land is being held for water supply needs, not forestry practice. Forest expenditures, like all watershed costs of whatever description, are chargeable to obtaining a potable water supply. It follows, therefore, that no forest work may be done that will be detrimental to the water supply, and that net forest income is purely secondary to the primary object of water production. On the other hand, it is recognized that a forest in its natural state may often furnish the same ideal conditions for water purification as a well managed stand, so that no money is expended for forest practice unless it is established that such practice will more than pay for itself.

What good purpose, it may be asked, does a forest serve on a watershed? Exhaustive research has shown very definitely that trees, although they transpire water, do produce a ground condition that retards runoff and absorbs moisture, so that the ground itself, when timbered, supplements the storage capacity of the catchment basins. The forest also serves to purify the water by a natural method of filtration, so that when it is delivered to the stream it is not only pure but good to the taste.

Fire Protection and Forest Practice

Adequate fire protection is of primary importance, because without it there is no point to any other forest practice. Fire not only destroys the merchantable and young timber, but also destroys the humus cover of the ground so that its moisture-retentive power is greatly reduced. Lowdermilk of California, who has done a great deal of work in this direction, showed in one series of experiments on burned plots that erosion was from 73 to 1,196 times as great on burned-over soil as on litter-covered plots ranging from sandy clay loam to clay loam. Prac-

tically all erosion and silt arises from burned, denuded and nonforested land, except for a small amount due to cutting of stream banks.

In an 11-year period, 1935 to 1945 inclusive, 1,239 acres were burned over by 194 separate fires. Four of these fires burned more than 100 acres each. Many of the fires were repeated burns by railroad fires over the same areas, which generally consisted of old meadow land along the railroad, rather than timberland. This average of less than 0.4 per cent, or one acre in every 250 each year, compares favorably with the year 1930, when more than a fourth the total acreage burned over.

Fire prevention measures consist of doing those things necessary to hold fires to a minimum before they occur. One such measure is to develop and hold a proper attitude on the part of local residents who are not employees of the organization, so they will help rather than hinder in keeping fires down. Such an attitude has been developed over a period of years and is due not to one man but to a whole group of men in authority in the water department.

The CCC contributed very materially to providing better forest fire control. Among projects undertaken and completed on the watershed may be listed:

1. The construction of 24 miles of truck trails to serve the dual purpose of making merchantable timber accessible and of providing better fire control.

2. Ten miles of fire break, a steel fire tower, many water holes, spring holes and foot bridges were constructed at strategic points throughout the watershed.

3. Twenty picnic tables, 17 fireplaces, and two combination latrines were constructed, and other work necessary to control transient travel through the watershed was done in the three picnic areas.

Tree Plantings

As stated earlier, the planting of trees comprises the first forest work on the watershed exclusive of fire protection. To date, 2,871 acres have been planted and about 50 per cent of the plants were raised from seed in a watershed nursery operated by the CCC. Allowing for the 163 acres burned over after planting and the losses from damage by deer, by drought immediately after planting and the like, there are probably in excess of 2,400 acres of established plantations on the watershed today. These plantations serve three purposes:

1. Established as they are on old fields, they decrease runoff. In addition, coniferous plantations retard the melting of the snow underneath them, so that, in a spring thaw, this moisture is delivered to the reservoirs a great deal later than the moisture from the snow underneath the hardwoods.

2. The land is put to work, producing products of future value.

3. The aesthetic value, or general appearance, of the watershed is improved.

These plantations are generally of conifers, such as white and red pine and Norway spruce, but a large number consist of oak and other hardwoods native to the region. Although much of the acreage consists of so-called "solid plantings," a large area is spot planted. If an old field has lain idle for many years, it gradually grows up to species that seed in naturally from the areas surrounding it. This growth may be gray birch, fire cherry, thornbush, wild apple, sweet fern or the like, of no economic value. Economics will not justify cutting out this material and

planting, but economics will justify planting the openings. In such a "spot" planting, only that part of a field actually planted is included in the planted acreage total.

The coniferous trees planted today are generally 3-year seedlings or transplants of white pine and Norway spruce, and the hardwoods are generally acorns or 1-year oaks. These will range in size from about 3 to 12 in. above the root crown. Seedlings are generally used on the more open ground, but, where grass and other competition is heavy, transplants are much to be preferred because of their more compact and heavier root system.

Silvicultural Treatment

Among the many forest activities undertaken by the CCC while it worked on the watershed must be mentioned the 3,419 acres of woodland that received silvicultural treatment. This forest culture operation removed dead and diseased wood at the rate of about four cords per acre, much of which went to Newark to provide fuel for those on relief. As a result of these cuttings, the rate of growth on valuable trees has increased and the density of stocking in the younger age classes has been improved.

Insect and Disease Control

No picture of forest management is complete without at least a mention of insect and disease control. Every tree, like every garden plant, is subject to damage from insects and disease. In general, the trees subject to most damage from native insects and diseases are those trees grown out of their natural location, but an insect or a disease introduced from abroad is generally the most dangerous, because our native growth has not built up a resistance to these introduced enemies. The form of control varies with almost every insect or disease, though certain general patterns of control are followed. It may sometimes be necessary to remove trees or groups of trees during a specific period of the year, to remove infected parts of trees or to control certain insects by the release of laboratory-propagated parasites. A good proportion of the forester's time is spent on insect control during the period of spring growth.

Lumber Sales

The policy in the past has been to make sales that will increase the productivity of the forest or the quality of the stand, or to salvage burned or dead stumpage while it still has some value. These sales are made with no other city cost than that of supervision.

With proper management it is believed that on the better natural stands the growth rate can be increased as much as threefold over present rates. The great bulk of the watershed forest is between 30 and 50 years old, as most previous owners clear-cut the timber areas before selling to the city. It will therefore be another 20 to 40 years before any large quantity of good merchantable timber will be available for sale.

The largest net income from forest sales in recent years occurred in 1943, when \$9,578.20 of the total resulted from the sale of Norway spruce for Christmas trees. This spruce had been planted from 7 to 11 years earlier and averaged about 7 ft. in height. Slightly under half the total resulted from thinnings in planted stands at 40¢ per tree stumpage. In this sale, advantage was taken of an unusual condition, as ap-

pearances indicated that, because of the war, there would be no Balsam fir available from the Northeast for the Christmas season. Newark's expense in this sale consisted of advertising for bids and providing a qualified laborer to go through the stand and point out and tally the trees to be removed. The entire sale required a period of less than three weeks and removed trees that would otherwise have died in natural competition.

For a more accurate picture of current normal sales, the forest income for 1945 is shown in Table 1.

TABLE 1

Forest Income for 1945

Laurel and boughs	$252.00
Live timber stumpage	3,214.05
Dead timber stumpage	754.43
Sale of live spruce	134.65
TOTAL	$4,355.13

The laurel sale ($27.00) might be termed an accommodation sale. One or two stems were broken off each plant so that, without very close inspection, the place of their removal could not even be noticed.

The boughs ($225.00) are sold from pine plantations prior to Christmas and the purchaser is required to use a pruning saw and cut the boughs flush with the main stem of the tree. The cost of the pruning, were it done with watershed labor, would exceed the value of the boughs removed, and the pruning, properly done, produces a much higher grade log at maturity of the tree.

Live timber stumpage netted $3,214.-05. A sale of live timber is handled in a manner established by experience. A stand of, say, 100 acres may contain trees which have obtained all or most of their growth, and the current rate of growth is, therefore, far below what the stand might produce. A number of dead and diseased trees are found on each acre and, if left uncut, will cause many of the older trees to die within a few years. It is decidedly advantageous to such a stand to make a cutting.

The area is first mapped out by plane table and chain survey, and the boundary of the proposed sale area marked in the forest. The assistance of the state forest organization is then solicited to expedite work and a complete tally is made of all trees eight inches and over in diameter, to determine the exact inventory of the stand. Examination of the stand and past experience with similar stands may indicate that one-third of the volume may be removed with the expectation that another equal cut may be made in 25 years, during which the average annual rate of growth of the residual stand will increase by 50 per cent.

The stand is then marked for cutting to remove one-third the volume. Generally all the oldest and all the merchantable but poor younger trees are marked. The marking is done by blazing the trees at breast height and also blazing and stamping below stump height as a check against the logger. All trees marked for cutting are tallied by species, diameter and merchantable log length.

A statement or prospectus sheet is then sent out to prospective buyers by the central office. This statement shows the exact number of trees of each size and species to be sold and the total number of board feet a buyer may expect to cut from the area. With this prospectus sheet are a map of the area and a sample contract. Any interested party may look over the area alone or with the forester and submit his bid on

the form contract. All bids are opened in the City Hall at a specified time and the contract is awarded to the highest responsible bidder.

The buyer places a cash deposit with the city for proper performance of the contract and begins work. The logs are scaled in the field as cut and paid for as removed. The contract contains penalty clauses for unnecessary damage to natural reproduction, removing unmarked trees and the like.

This method of sale was worked out by the State Forest Service for private forest ownership and has been modified only slightly to meet municipal requirements. The total cost of all forest work, from the original mapping to closing of the sale, is less than 10 per cent of the money received from the logger and very definitely more than pays for itself in the greater value received for the timber, the increased rate of growth and the greater value of the residual or remaining stand.

Sales of dead stumpage in 1945 aggregated $754.03 and consisted of chestnut, burned pine, gray birch and oak. The burned stumpage resulted from a fire, and most of it was sold by the cord on the stump. Most of the burned pine was later manufactured into roofing paper and much of the birch was used in making artificial log fire sets for apartment fireplaces.

The sale of live trees ($134.65) consisted of planted trees sold at a specified price per tree in the ground. Of this amount, $70 was for two Norway spruce 30 ft. in height, which were sold to a commercial nursery for resale to municipalities as community Christmas trees.

As all municipal workers know, the "red tape" involved in municipal work tends to make proper management more difficult than is the case with private ownership. This is particularly true of sales. Throughout the forest there will be found from time to time small groups of trees that should be removed, but the value of the stumpage is too small to justify the cost of surveying a boundary, preparing a map, making an accurate estimate and advertising for bids. Unless the municipal forester has the labor and equipment available to do the logging, he may be forced to let the timber rot on the stump. The private forester, however, by virtue of the greater power and responsibility vested in him, can sell the stumpage directly by telephone or personal contact without costly preliminaries.

It may be well to point out that about 20 years hence, as part of the large acreage of immature forest reaches merchantable size, the watershed can and no doubt will be an important factor in the economic life of the community. An eventual annual cut of from 4,000,000 to 6,000,000 fbm. of lumber and 5,000 cords of wood does not appear overly optimistic. Although the soil is generally poor and the topography for logging rough, the proximity to the metropolitan area offers many and varied markets for the watershed forest products.

Ground Water Supplies of Wisconsin

By Harvey E. Wirth

A paper presented on Nov. 16, 1946, at the Wisconsin Section Meeting, Green Bay, Wis., by Harvey E. Wirth, Sr. Asst. San Engr., Bureau of San Eng., State Board of Health, Madison, Wis.

IN the past, the general availability and adequacy of ground water resources in Wisconsin have been well established by geologic surveys and writings and by the actual history of the use of the state's ground waters in public, private, rural, institutional and industrial developments. Through the records of the State Board of Health, detailed information is available on the extent to which ground waters are developed for use as public water supplies. It is known, for example, that there are now 370 ground-water supplies, consisting of 734 wells, 23 springs and 148 infiltration galleries, supplying 391 communities with a total population, according to the 1940 census, of 952,000. These 370 water supplies, all but 12 of which are municipally, co-operatively or federally owned, comprise 93.25 per cent of the recognized public water supplies in the state and serve approximately 48 per cent of the population using water works systems and more than 30 per cent of the state's total population.

It would indeed be rash to attempt to state exactly the total number of private and rural wells and springs in the state which discharge water to the surface for drinking purposes. The total would surely run into four figures.

There are also numerous well developments for industrial use, processing water, air-conditioning, and cooling and condensing purposes. In time, the information made available on large industrial wells— those drawing in excess of 100,000 gpd.—will become more extensive, since Sections 6, 7 and 8 of Statute Law 144.03 require a permit from the State Board of Health before they can be developed. Another large group of users of ground water is made up of the many state and local institutions that either have individual wells or rely upon one of the 370 developments previously mentioned. It is obvious, therefore, that Wisconsin has been blessed with an adequacy of ground water. Today, however, the supply is less certain. In recent years the problem of decrease in underground flows has developed in the Green Bay, Milwaukee and Waukesha areas. Increased use of water by industrial plants, developments in suburban areas as private and semipublic supplies and the field of air-conditioning are but some of the factors creating anxiety in these critical areas.

Sources of Supply

The rock formations in Wisconsin fall into three great geologic periods. The first, or earliest, is the Pre-Cambrian; the second is the Paleozoic; and the third is the Pleistocene or Glacial.

The Pre-Cambrian formation provides no large amounts of water, as are needed by public supplies. Containing the granite deposit, the formation serves as a relatively impervious basement controlling the artesian flows, but does not exert a very extensive influence on the ground water of the state.

The second, or Paleozoic, period is made up of such well-recognized formations as the Potsdam sandstone, Lower Magnesian limestone, St. Peter sandstone, Galena-Platteville limestone and the Niagara limestone laid down in geologic time in the order named. All of these are aquifers yielding large to moderate supplies, with the Potsdam and St. Peter sandstones being the most prolific of the five mentioned.

Finally, the Glacial period is recognized for its large supplies as furnished from the thick deposits of valley alluvial sand and gravel and its moderate supplies from the variable thickness of loess in the uplands.

Of the 734 wells presently comprising the public well supplies, some sort of information on geological formation is available on 708. As a good number of these wells draw upon more than one formation, the tabulation made totaled 990 instances of water drawn from one or a series of the Mantle, Niagara, Galena, St. Peter, Lower Magnesian, Potsdam and Granite horizons. The listing in Table 1 shows that Potsdam, Mantle and St. Peter are the formations most relied upon by the developers of public water supplies. More than 68 per cent of the logs show that one or a combination of these water horizons supplies the municipality with drinking water.

A review of the ground water developments in Wisconsin that serve as public water supplies shows the following interesting facts: Of the 370 supplies, 354 are classed as well supplies, 12 as springs and 4 as infiltration galleries. The shallowest well is 4 ft. deep and is located at Caddott. It is spring-fed and is in the Mantle formation with granite not very far beneath, in fact, outcropping in the area. The deepest well is the Newhall Ave. well at Waukesha, 1,995 ft. deep. It is 18 in. in diameter at the surface and 12 in. at the bottom. Its supply is drawn from the Galena, St. Peter, Lower Magnesian and Potsdam formations. The average depth of all public well supplies is 372 ft. The average drilled well diameter at the surface is 15 in. This shows the definite tendency of starting wells at greater diameter than the usual 6 or 8 in. characteristic of the early well supplies. It shows also that wells are being double-cased and grouted in conformity with good practice and health protection. Of the 354 well supplies, 186 rely upon a single well; in short, 52.5 per cent of the public well supplies find their needs satisfied with but one source. This is not an ideal situation and, as experience

TABLE 1

Geologic Formations Supplying Wisconsin Wells

Formation	Wells Supplied No.	Wells Supplied %
Mantle	213	21.5
Niagara limestone	80	8.1
Galena-Platteville limestone	108	10.9
St. Peter sandstone	145	14.7
Lower Magnesian limestone	117	11.8
Potsdam sandstone	317	32.0
Granite	10	1.0

has shown, all too many desire stand-by units and plague the Board of Health with requests for permission to designate an industrial well as an emergency source of supply. The evils of cross-connections are then introduced by those who take it upon themselves to establish such connections unknown to the board—until surveys show their existence. The largest community served by a single well is Waupaca, with a population of 3,458.

The greatest number of drilled wells developed by one community—La Crosse—for its public water supply is 28. That system consists of 24 drilled wells arranged in 6 groups of 4 wells each in one well field and 4 additional wells at various points in the city. The city of Superior surpasses La Crosse in number of units, having 144 infiltration wells consisting of jetted and lateral wells. Until recently the city of Wisconsin Rapids used numerous wells too, having had 80 dug and drilled units. A new well field has been established, and the city now requires only 6 drilled wells.

Board of Health records list 23 springs serving as public water supplies for 5 incorporated communities: Chippewa Falls, Lancaster, Norwalk, Osceola and Phillips; two towns: Commonwealth and Pence; and five subdivisions: Davis and Spring Water Corp. at Fontana, Glen Haven, and Buena Vista Assn. and Glenwood Springs Assn. at Walworth. Chippewa Falls, with 8 springs, has the greatest number. Phillips, with one spring at a depth of 3 feet, has the shallowest source of supply of any public water development in the state.

Besides Superior, the records show that there are 3 incorporated communities that have developed infiltration wells: Nekoosa, Niagara and Port Edwards. Niagara has the shallowest of these developments with infiltration tile at 8-ft. depth.

The city of Manitowoc is the only community, to date, which has made use of the Ranney design. It has two such developments, one 66 ft. deep, cased 60 ft., and one 86 ft. deep, cased 71.5 ft. In the latter, there are 21 8-in. steel tubes branching from the well, representing a total distance of 443 ft. and containing 48,730 slotted holes for the water to enter.

Ground Water Treatment

Of the 370 ground-water supplies, 100 have some form of treatment, varying from simple aeration to softening and iron removal. The 100 treatment plants serve a total population of 602,204, or more than 63 per cent of the population served by ground waters.

TABLE 2

Water Treatment Plants in Wisconsin

No.	Type of Treatment	Population Served
1	Lime softening	607
7	Lime softening, iron removal	29,145
9	Zeolite softening	21,933
9	Zeolite softening, iron removal	9,933
21*	Iron removal only	83,689
9	Aeration	44,441
35	Gas chlorination	350,157
21	Hypochlorination	22,700
5	Chlorammoniation	36,728
5	pH control	2,871
	Total	602,204

* In addition to iron removal in softening plants.

This is 18 per cent of the state's population and 29 per cent of the population served by some form of public water supply. Table 2 gives a breakdown of

number and type of these treatment plants and the populations they serve.

In addition, a lime softening plant is in the design stage for the city of Berlin (population 4,247), and a zeolite hardness and iron removal plant is planned for the new ground development at Whitehall (population 1,035).

plants to be installed and placed in operation was the zeolite plant in Randolph. The largest installation, at Antigo, was placed in service in 1939.

Table 4 shows that 40 ground supplies use gas chlorination, of which 5—Brodhead, Eau Claire, Jefferson, Kewaunee and Montreal—also add am-

TABLE 3

Water Softening Plants

Location	Type of Plant	Rated Capacity *1,000 gpd.*	Remarks
Antigo	Lime	2,000	Also iron removal and chlorination
Cambria	Zeolite		Also iron removal
Cambridge	Zeolite		
Campbellsport	Zeolite		Also iron removal
Chilton	Zeolite	124	Also iron removal
Colby	Zeolite	115	Also iron removal and chlorination
Columbus	Lime	1,000	Also iron removal
Elkhorn	Lime	1,000	Also iron removal
Evansville	Lime	720	Also iron removal and chlorination
Galesville	Zeolite	140	Also iron removal
Green Dale	Zeolite	1,000	Also iron removal
Hilbert	Lime	104	Also hypochlorination
Lake, Town of	Zeolite	1,150	
Little Chute	Zeolite	180	
Lomira	Zeolite	288	Also iron removal
Manawa	Zeolite	120	
Markesan	Zeolite		Under construction
Omro	Zeolite		
Pardeeville	Zeolite	216	
Platteville	Lime	1,000	Also iron removal
Port Edwards	Zeolite	218	Under construction
Poynette	Zeolite	130	Also iron removal
Sheboygan Falls	Zeolite	700	
Waupun	Lime	1,000	Also iron removal
Williams Bay	Lime	820	Also iron removal
Randolph	Zeolite	130	

Table 3 shows the type and capacity of the softening plants treating ground water supplies. The filtration plants in the table comprise 18 pressure zeolite filters and 8 gravity or mechanical sand filters. The first lime softening plants to be installed were those at Evansville and Columbus in 1933; the first zeolite softening plant was that at Galesville in 1935. The latest of the softening

monia. Three of the supplies—Cuba City, Shawano and Stevens Point—have chlorination facilities for emergency standby use only. All but 3 of the above 40 supplies have well sources, the spring at Phillips and the infiltration galleries at Niagara and Superior being the exceptions. There are 21 ground supplies dependent upon hypochlorination facilities with two—Avoca

TABLE 4

Chlorination Plants in Wisconsin

Location	Type of Chlorination*	Remarks
Allouez	C	
Antigo	C	Also softening and iron removal
Athens	C	
Avoca	H	Emergency only
Baraboo	C	
Belleville	H	
Beloit	C	
Brillion	H	
Brodhead	C	Also ammoniation
Cadott	H	Also pH control
Chilton	C	Also softening
Clyman	H	
Cornell	C	Also pH control
Crandon	C	Also pH control
Cuba City	C	Emergency only
Darlington	C	
Depere	H	
Dodgeville	H	One well only
Eau Claire	C	Also ammoniation
Edgar	H	Also iron removal
Elkhorn	C	Also softening and iron removal
Fennimore	C	
Fond du Lac	C	
Gilman	H	Also iron removal and pH control
Glidden	H	
Green Bay	C	
Greenwood	C	
Hilbert	H	Also softening
Juneau	C	Also iron removal
Kewaunee	C	Also ammoniation
Lake Geneva	C	Also aeration
Lancaster	H	
Lodi	H	
Loyal	C	
Madison	C	
Manitowoc	C	
Marathon	H	Emergency only
Marshfield	C	Only 50% of supply
Medford	C	
Mellen	H	
Mineral Point	C	
Montreal	C	Also ammoniation
Niagara	C	
Osseo	H	Also iron removal
Phillips	C	

* Gas chlorination indicated by "C"; hypochlorination by "H."

TABLE 4—*Continued*

Location	Type of Chlorination*	Remarks
Port Edwards	H	Softening and iron removal plant in construction
Prairie du Sac	C	Only one well
Randolph	C	Also iron removal and pH control
Reedsville	H	
Ripon	C	Also iron removal
Shawano	C	Emergency only
Sheboygan Falls	C	
Spencer	H	Also iron removal
Stevens Point	C	Emergency only
Stratford	H	
Sturgeon Bay	C	
Superior	C	Also iron removal
Wausau	C	Also iron removal
Wisconsin Rapids	C	Also iron removal

* Gas chlorination indicated by "C"; hypochlorination by "H."

and Marathon—designated for emergency use only. All of the 21, with the exception of the spring at Lancaster and the infiltration galleries at Port Edwards, are well supplies.

Quality of Ground Water

For the past year and a half, the State Board of Health, in co-operation with the State Laboratory of Hygiene, has been conducting a survey of the chemical properties of Wisconsin's public water supplies. As of Nov. 1, 1946, 285 of the 370 public ground water supplies have been sampled and chemical analyses have been reported on the 522 wells, 12 springs and 5 infiltration galleries that make up their sources.

The softest ground water supply is at Lyndon Station, where the hardness is 20 ppm. and the total alkalinity 6 ppm. The supply is derived from the Potsdam sandstone at a depth of 200 ft.

The hardest public ground water supply is found at Sheboygan Falls. Well No. 4 has a total hardness of 1,000 ppm. and well No. 1, 830 ppm. The corresponding total alkalinities are 174 and 178 ppm. Well No. 4 is 610 ft. deep; No. 1 is 421 ft. deep; and both derive their supplies from the Niagara limestone. Sheboygan Falls has zeolite softening; hardness of the finished water is 80 ppm.

The small community of Hazel Green, near the Illinois border in the southwest corner of the state, has two wells with hardness contents of 940 and 790 ppm. and total alkalinities of 432 and 380 ppm. respectively. This supply is derived from the Galena limestone and St. Peter sandstone at a depth of 395 ft. There is no softening plant at Hazel Green (population 601). The iron content of the water is 3.2 ppm., with no provision for removal. Table 5

TABLE 5

Total Hardness of Ground Water Supplies

Total Hardness	Supplies	
ppm.	*No.*	*%*
Over 600	7	1.3
500–600	5	0.95
400–500	33	6.25
300–400	171	32.3
200–300	153	29.0
100–200	88	16.3
Under 100	82	15.3

shows that approximately 70 per cent of the ground waters supplying public water works have objectionable hardness.

The supplies containing the greatest concentration of iron are the new well at Whitehall and the Group 6 wells at La Crosse, both having 7.2 ppm. of total iron. The Whitehall well is 233 ft. deep and draws from the Potsdam sandstone. On July 19, 1946, plans were approved for a treatment plant consisting of iron and hardness removal. Either a zeolite unit or zeolite in combination with a sand filter unit was proposed. The Group 6 wells at La Crosse consist of 4 wells 118 ft. to 128 ft. 10 in. deep. The supply is not treated for iron removal; however, only 12.2 per cent of the city's supply is derived from this group. An iron removal plant is constructed for the Rosey Boulevard well. There is no record of total iron in this supply. An iron analysis of the group of 6 wells made February 16, 1934, shows only 1.0 ppm. Either the 1945 analysis is in error, or continuous pumping of these wells has greatly increased the iron content. Iron in the La Crosse distribution system tests 0.40 ppm.

A check of the 539 current chemical reports on ground water supplies shows that nearly 40 per cent have no iron at all, 31.5 per cent have between 0.1 and 0.3 ppm. of iron, 17 per cent have between 0.4 ppm. and 1.0 ppm. of iron, and 14.5 per cent have in excess of 1.0 ppm. of iron. Hence, more than 30 per cent of the ground supplies have objectionable amounts of iron.

Well No. 2 at Wausau has the highest concentration of total manganese of all ground supplies currently tested to date. This well tests 2.88 ppm. It is 96 ft. deep and draws from the Mantle formation. Wausau provides for iron and manganese removal; the filter effluent shows no manganese. The Stevens Point Well No. 3 shows 2.72 ppm. of manganese; it is 52 ft. deep into the Mantle formation. The well is used for stand-by purposes only.

No manganese is found in 87 per cent of the ground supplies; 7.4 per cent show concentrations between 0.1 and 0.3 ppm., and approximately 5.5 per cent show manganese in excess of

0.3 ppm. Hence, just a small fraction of the public ground water supplies have objectionable manganese.

The Farlin Ave. well at Green Bay shows the highest concentration of fluorides of all supplies currently tested. This well contains 2.8 ppm. of fluorides, is 956 ft. deep into Galena, St. Peter, Lower Magnesian and Potsdam formations, and produces 19 per cent of the city's supply. All the Green Bay wells contain fluoride in excess of 1.00 ppm. The Cass St. well has 2.7 ppm. of fluorides; the Ninth, Mason and Gray St. wells have 2.0 ppm., and the Shawano Ave. and Seventh St. wells have 1.6 ppm. The Green Bay wells vary in depth from 804 to 956 ft. and draw from the Galena, St. Peter, Lower Magnesian and Potsdam formations. Preble, Allouez and De Pere wells show 2.8 ppm. of fluorides also.

Of the public ground water supplies tested in the present survey, 46 per cent show less than 0.1 ppm. of fluoride; 46 per cent have between 0.1 and 0.5 ppm.; 3.0 per cent have between 0.5 and 1.0 ppm.; and 5.0 per cent have more than 1.0 ppm. It appears from this record that approximately 2 per cent of the supplies had fluoride at the optimum concentration of 1.00 ppm.

Examination of the record, to date, shows that the chloride content of the public ground supplies is far below the maximum of 250 ppm. permitted by the 1946 U.S. Public Health Service drinking water standards. The chloride content of 62.5 per cent of the supplies is less than 10 ppm., 31 per cent have between 10 and 30 ppm. of chlorides, 4 per cent have between 30 and 50 ppm. and 2.5 per cent have over 50 ppm. The No. 4 Well supply at Sheboygan Falls has the highest chloride content so far examined—355 ppm. The lowest chloride content—1.00 ppm. —is found at Biron, in a dug well 30 ft. deep into the Mantle formation.

Sulfates in public ground-water supplies vary from 0 ppm. at Mauston's No. 2 Well and Beloit's No. 9 Well to a high of 660 ppm., with most supplies in the range of 50 to 250 ppm.

Seven supplies of those analyzed show total solids in excess of 1,000 ppm., the Sheboygan Falls No. 4 Well testing 1,842 ppm. In all, 42, or 7.8 per cent, show solids in excess of 500 ppm. Total solids varying from 300 to 500 ppm. are found in 38.5 per cent of the supplies; 45.5 per cent show total solids of between 100 and 300 ppm.; and 8.2 per cent show less than 100 ppm. The Biron well, with 40 ppm., has the lowest content of total solids.

TABLE 6

Comparative Analysis of Two Wisconsin Supplies

	Hazel Green	Lyndon Station
Hardness, total, *ppm.*	940.0	20.0
Alkalinity, phenolphthalein ($CaCO_3$), *ppm.*	0.0	0.0
Alkalinity, total ($CaCO_3$), *ppm.*	432.0	6.0
Calcium (Ca), *ppm.*	210.6	1.25
Magnesium (Mg), *ppm.*	89.0	0.9
Iron, total (Fe), *ppm.*	3.2	0.2
Manganese, total (Mn), *ppm.*	0.06	0.0
Chlorides (Cl), *ppm.*	80.5	10.0
Sulfates (SO_4), *ppm.*	510.0	1.5
Fluorides (F), *ppm.*	0.25	0.1 –
Total solids, *ppm.*	1,356.	42.0
H_2S (qualitative), *ppm.*	0.2	0.0
pH	6.9	7.5

It is interesting to note the extremes in analyses found at Hazel Green and at Lyndon Station. Lyndon Station is a small community of 354 population, about 10 miles north of Wisconsin Dells, located on U.S. Highways 12 and 16. The comparative mineral contents

of these two supplies are shown in Table 6.

Potability of Supplies

The record of potability of Wisconsin ground water is considered good; only five times in the history of ground supplies have there been actual waterborne outbreaks. The last one occurred in early October 1929, when altering the course of a river channel accidentally polluted the Fond du Lac supply. The story and the statistics on this dysentery and typhoid fever epidemic are well known. The moral of that outbreak is the ease with which ground supplies can become unsafe when surface water is permitted entrance into the underground formations, particularly into the various limestones. Cross-connections with polluted private supplies account for the other four outbreaks, all in the 1920's.

A review of all bacteriological analyses submitted over the course of one year could be checked and statistics reported. That would be a tremendous time-consuming task, and no attempt to do so has been made. The results would merely confirm the board's day-by-day record that most of the supplies meet minimum requirements of the U.S. Public Health Service drinking water standards.

Of course, unsafe samples come through. There are a number of poor ground supplies that should be redeveloped or certainly protected by continuous chlorination. The mere fact that water is being drawn for public consumption from an average depth of 372 ft. below the surface is not in itself a protection. The history of public ground water supply has proved that to water works superintendents and health officials everywhere.

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **34:** 412 (Mar. '42) indicates volume 34, page 412, issue dated March 1942. If the publication is paged by the issue, **34:** 3: 56 (Mar. '42) indicates volume 34, number 3, page 56, issue dated March 1942. Initials following an abstract indicate reproduction, by permission, from periodicals, as follows: *B.H.—Bulletin of Hygiene (British); C.A.—Chemical Abstracts; P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (British); I.M.—Institute of Metals (British).*

BACTERIOLOGY

Quantitative Bacteriology. Communication No. 3. Death and Arrest of Growth of a Bacterium in the Light of Death Curves. H. Schubert. Zentr. Bakt. (Ger.) **I.** 150: 66 ('43); Zentr. ges. Hyg. (Ger.) **51**: 370 ('43). Rate of death in culture of bacteria usually follows equation of monomolecular reaction. Death of bacterium monomolecular reaction involving so-called acceptor, which is carrier of life similar to molecule. Another part of bacterium, multimolecular soma, experiences only arrest of growth. This thesis supported by math. anal. of death-time curves; has important bearing on theory and practice of disinfection.—*W.P.R.*

Tracing the Source of Water Contamination by a Bacteriological Method. L. Masurczak. Mitt. Lebensm. Hyg. (Ger.) **36**: 393 ('45). Well which had been used as source of drinking water for 50–60 yr. found to be contamd. with typhus organisms. Origin of well water unknown, but several small surface springs existed in surrounding area. From 250–1000 ml. of *Serratia marcescens* culture, 15,000,000,000 per ml., added to each surface spring in succession until in one case test organism recovered from well.—*C.A.*

Simplified Technic for the Bacteriological Examination of Water. Bol. Obras Sanit. Nacion (Arg.) **8**: 88 (Aug. '44). When *Esch. coli* added to Buenos Aires tap water and maintd. at various temps., marked fall in number of organisms took place after 24 hr. at 2°C. and 37°C.; at 20°C., 50% fall took place in 48 hr., followed by multiplication of organisms at 6–7 days. Similar results obtained with *Aer. aerogenes*. Samples of natural water investigated in same way, but without addn. of bacteria. Variation in number of coliforms least marked at 2°C.; decrease took place at higher temps. Deep well water with high bact. count showed little increase in coliforms in 96 hr. at 2°, 20° and 37°C.; water with low bact. count showed rise at 2°C., no change at 20°C. and slight fall in numbers at 37°C., all over period of 96 hr. Surface water from River Plata tested similarly showed fall in number of coliforms, most marked at 37°C. Comparison given of 3 sampling technics: (a) 250 ml. taken and packed in ice; (b) 100, 10 and 1 ml. taken and sent without ice; (c) as (b), but with addn. of nutrient agar to each sample. Method (a) gives best results, but for rural dists. where ice not available method (c) will give satisfactory results.—*B.H.*

Influence of pH and Temperature on the Survival of Coliforms and Enteric Pathogens When Exposed to Chloramine. C. T. Butterfield & Elsie Wattie. U. S. Pub. Health Repts. **61**: 157 ('46). Results represent avg. from 193 series of expts. conducted at (*a*) pH 6.5, 7.0, 7.8, 8.5, 9.5 and 10.5; (*b*) two temp. ranges, 2° to 6°C. and 20° to 25°C.; (*c*) various ratios of Cl and ammonia N, and with species of *Escherichia*, *Aerobacter*, *Pseudomonas*, *Eberthella* and *Shigella*. Materials and procedures used fully described, and factors concerned in use of chloramine briefly discussed. Results suggest following conclusion: Length of exposure of bacteria in water to chloramine and amt. of chloramine present primary factors governing rate of bact. kills. Under favorable conditions, i.e., at pH 7.0 and temp. of 20° to 25°C., 100% kills cannot be expected in less than 20 min. with chloramine residuals of about 1.2 ppm.

H-ion concn. has pronounced effect on bactericidal activity of chloramine, activity being diminished with each decrease in H-ion concn. For instance, if under given conditions at room temp., 0.6 ppm. of chloramine at pH 7.0 produced 100% kill in 40 min., then at pH 8.5, under otherwise identical conditions, approx. 120 min. would be required, and at pH 9.5, 240 min., or to produce 100% kill in 40 min. at pH 8.5, chloramine residual would need to be increased to about 1.5 ppm. Lowering of temp. retards bactericidal activity of chloramine. Reduction of 20°C. in temp. (20–25°C. to 2–6°C.) requires 9 times exposure period, or 2.5 times as much chloramine to produce 100% kill. Thus, when high-pH water superimposed on low temp., very marked retardation of bactericidal activity must be anticipated. Under certain conditions some strains of *Eber. typhosa* and *S. sonnei* appear slightly more resistant than some strains of *Esch. coli.;* however, not any more resistant than strains of *A. aerogenes* studied. Presence of excessive amts. of ammonia nitrogen (Cl_2:N ratios to 1:25) did not markedly reduce bactericidal eff. of resultant chloramines. Duration of contact time (0 to 68 hr.), of chloramine components, Cl and NH_3, did not alter bactericidal properties of chloramine. Chloramines much less efficient as bactericidal agents than free Cl. Thus, to obtain 100% kills with same period of exposure required about 25 times as much chloramine as free Cl, and to obtain same kill with same amts. of Cl and chloramine under same conditions required approx. 100 times exposure period for chloramine.—*C.A.*

Slime-Producing Coliform and Coliform-Like Bacteria. J. R. SANBORN. J. Bact. **48**: 211 ('44). Coliform bacteria in pulp and paper mills usually originate in water supply although sometimes derived from wood or fibrous matter used as raw materials. Conditions in pulp and paper mills very favorable for growth of micro-organisms. Examn. of slime from 340 mills showed that in 52.6% of mills coliform bacteria prevalent in slime. Of 175 samples of slime examd. for coliform bacteria 94% contained *Aerobacter* as principal cause of slime. *Aerobacter cloacae* principal constituent of slime in 59% of samples. 6% of cultures isolated more closely related to *Escherichia* than to *Aerobacter*. Intermediate groups sometimes present in assn. with typical coliform organisms. Bacteria generally controlled in pulp and paper mills by use of chlorinated water in plant; concn. of residual chlorine varies from 0.5 to 2.0 ppm. Types of *Esch. coli* normally found in pold. water, intermediate coliform types, *Alcaligenes faecalis*, *Pseudomonas fluorescens* and *Pseudomonas viscosa* can be controlled by residual concns. of chlorine of from 0.4 to 0.8 ppm. Under certain conditions in pulp and paper mills, control of resistant mucoid variants of *Aer. aerogenes* and *Aer. cloacae* may require residual concns. of more than 1.0 ppm. chlorine. Lab. tests made with 125 compds. to test their effectiveness for controlling bacteria and fungi which cause slime. Of these compds., 45 controlled coliform bacteria to some extent. Trichlorophenate fractions, metallic salts of chlorinated phenols, chlorinated isopropyl phenols and various alkyl derivatives of halogenated phenols, in aqueous dilns. of 1:10,000 to 1:100,000, controlled all coliform organisms studied. Some of these chems. also tested under conditions of mill operation; they not only killed coliform organisms rapidly but also penetrated to deeper layers of fungal slimes. Mucoid variants of *Esch. coli* particularly susceptible to metallic salts of various phenolic compds., including salts of copper and mercury. In several cases compounds that failed to control *Aerobacter* very toxic to *Escherichia*. Mucoid varieties of *Aer. aerogenes* and of *Aer. cloacae* showed similar deg. of resistance to chems. tested. Lab. tests and experience in mills showed very good control of slime obtained by use of mixts. of compds.—*W.P.R.*

On the Disappearance of Esch. Coli and Fecal Streptoccoci (Enterococci) As a Result of Slow Sand Infiltration. T. FOLPMERS. Leeuwenhoek (Dutch) **7**: 104 ('41); Zentr. ges. Hyg. (Ger.) **50**: 580 ('43). At Rotterdam water works raw water, after settlement for 10 to 12 hr., flows first through Paterson filter plant and then through slow sand filter with medium 1.5 m. deep. Water either chlorinated after filtration or, in winter, treated with activated carbon before filtration. Detns. made microscopically and on special media of *Esch. coli* and fecal streptococci. Results of observations during '38–'40 given in tables. Fecal streptococci appeared in slow sand filter during cold weather from end of Nov. to end of Feb. or middle of Mar.; these organisms found in 5 ml. of effluent from slow sand filter at temps. below 1°C., but at temps. of 2° to 3°C. they began to disappear. Fecal streptococci detected in 0.2 to 25 ml. of effluent from Paterson filter plant from middle of Sept. to Apr.; from Apr. to Aug. not found in 100 ml.

Disappearance of these organisms due not to action of filter but to their destruction by ameba and other protozoa. During period of 12 hr. in Apr. number of bacteria fell rapidly; at beginning of period fecal streptococci detectable in 1 ml., but at end of period detectable only in 25 ml. During cold weather protozoa become encapsulated and no longer consume bacteria. In later investigations numbers of fecal streptococci and *Esch. coli* increased in effluents from both filters at temps. of 2° to 3°C. In effluent from slow sand filter fecal streptococci appeared later in year and disappeared earlier than did *Esch. coli*. Fecal streptococci in effluents from both filters less numerous than *Esch. coli*. It can be assumed that water free from fecal streptococci also free from typhoid bacteria. These types of bacteria more likely to be in water in winter; at this season water should be chlorinated.—*W.P.R.*

Silver p-Aminobenzene Sulfonate. A New Disinfectant for Water. Rev. Inst. Salubridad y Enfermedades Trop. (Mex.) **6**: 2: 123 (June '45). New chem. compd., silver para-amino-benzene-sulfonate, Sulfargenta, $NH_2C_6H_4SO_2O \cdot Ag$, has been described giving technic of prepn. Studies on bactericidal and bacteriostatic properties of this compd. and its application in water purif. made. Found that suspensions of *S. typhi* in blood serum sterilized with 0.00001 g. of this compd. per ml. of suspension. Cultures of *Esch. coli* completely inhibited with 0.0000001 g./ml. and contamd. water sterilized in from 4 to 6 hr. with 0.01 ppm.—*B.H.*

Precipitation of Iron Hydroxide in Drain Pipes. Lambert Wiklander. Kgl. Landtbruks-Ak. Handl. Tid. (Swedish) **84**: 358 ('45). Factor contributing to obstruction of drain pipes found to be pptn. of $Fe(OH)_3$ caused by bacteria, or by oxidation of Fe^{++} to Fe^{+++} by atm. O. Bact. pptn. more common. Iron bacteria, *Gallionella*, *Leptothrix ochracea* and *crassa*, and *Crenothrix*, which are autotrophic or mixotrophic, take up water contg. Fe^{++} in form of $FeCO_3$ or Fe humates on one side of their cell body and separate it as $Fe(OH)_3$ on other side as pale yellow or red yellow threads, spirals or tubes. Other organisms which ppt. Fe are Flagellata, Cyanophyceae, and some lower fungi. By oxidation of Fe^{++} to Fe^{+++} much weaker base formed, so that hydrolysis could take place at ordinary H-ion concn. and $Fe\text{-}(OH)_3$ sol be formed. Coagulation of sol requires certain pH in pipes. Steep drop of pipes, placing of apertures below water level, opening of ditches for several days and use of Cu wires in pipes and Cu jackets at pipe joints to poison micro-organisms, recommended to prevent their harmful action.—*C.A.*

LAW, LITIGATION AND LIABILITY

Commentary on the Water Act, 1945. Delwyn G. Davies. Wtr. and Wtr. Eng. (Br.) **49**: 159 & 203 ('46). Purpose of act is to put into effect new national water policy set out in white paper of Apr., '44. One intention of act is simplification of legislative procedure. Britain's water history permanent vendetta between authorities for power over water. Over 80% of water supplies of England and Wales controlled by local authorities. Law standardizes procedure and regulations governing work of water authorities, permits more money voted for water supply to be spent on water supply instead of legal bickerings. *Part I* (*Central and Local Planning*). Duty of provision of adequate water supplies placed on Minister of Health. Minister empowered to require local authorities to make surveys and proposals. Facilities for obtaining geological information for new wells prescribed. *Part II* (*Local Organization of Supplies*). Provides machinery for securing amalgamation or transfer of water works. Compulsory amalgamation only if continued separate existence involves inadequate supervision, waste or excessive costs. Ministerial powers will bring about improvement in admin. eff. of small water works which have not fulfilled obligations. Water works empowered to take water from any person or give bulk supplies with minister's consent. *Part III* (*Conservation and Protection of Reserves*). Where resources strained beyond limit, Minister has control over new wells through granting licenses for water abstraction and prevention of waste. New provisions standardize powers to prevent waste by passage of by-laws based on minister's model by-laws. Act of 1847 made it offense to bathe (or otherwise cause pollution) in stream

or reservoir of water works. Does not restrict land cultivation. Special savings given to highway authorities to perform road maintenance. *Part IV* (*Powers and Duties of Local Authorities and Water Works*). Water works enabled to construct works, raise capital and carry out general maint. and operation without Parliamentary confirmation. Principle established that where Parliament has fixed compensation for water, Parliament alone can alter it. For new developments, minister has to consider variables such as stream characteristics, other uses of stream, effects on land drainage and inland navigation. New code not enforced before October 1950 to give over 400 water works opportunity to review circumstances and avoid serious financial loss. Revision of water charges must be made with incorporation of new code. New act authorizes addnl. charges where water for gardens, cars or horses is taken through hose pipe or from outside tap. If aggregate water rates amount to $\frac{1}{8}$ of initial cost of extensions, pipes must be laid provided customers agree to take water for at least 3 yrs. Duty imposed by Act of '44, to supply water to rural localities where houses are, extended to all areas. Plans for new houses rejected unless satisfactory water supply is available. Local authority has power to insist on piped water supply to houses. Where owner of land requires supply for new buildings he may have water works lay necessary mains by guaranteeing yearly sum of $\frac{1}{8}$ cost of mains extension for 12 yrs. Obligations to supply for domestic purposes extended to non-domestic purposes. Water dischgd. into watercourse by water works must be free from silt, mud or matter prejudicial to fish life. Perhaps most serious flaw in act is requirement that notice be given when water is to be cut off from occupied house for recovery of rates or for "any other reason." Amount of work involved in giving notice, for example when main being tested for 2 hrs., considerable. Probable that every authority has contravened this section. (*Water Rates and Charges.*) Rate chargeable on net annual value of premises as shown in valuation list. Powers are granted to make min. annual charge and addnl. charges for watering of gardens, washing cars, etc. Minister empowered to revise rates on application of water or local authority, or 20 customers. *Part V* (*General*). *Penalties.* Throughout act penalties standardized into 3 prin. groups: minor offenses by consumers, up to £5 fine, for example, using hose during restrictions; up to £10, for wasting well-water in defined areas; and a max. of £200, for pollution of spring or well. If compensation water, this raised to £500. *Financial Provisions.* Expenses of Central Advisory Water Com. paid by minister. Powers of water cos. to issue stock clearly defined. Costs incurred by minister in making orders to fall on water authority concerned. *Public Supplies.* Where demand made for larger main to give satisfactory flow to hydrants, fire authority to pay extra cost and subsequent maintenance. *Supply and Communicating* (*Service*) *Pipe.* Major costs of maint. of service pipe in streets spread over all customers by placing responsibility on water works. (Customer must maint. portion under his own property.) *Stop Cocks* (*Corporation Cocks*). Responsibility for existing stopcocks rests with water works. Stop cocks to be located as near street boundary as practicable. *Fittings, Service Pipe.* Power granted to require separate service pipes to properties supplied by joint service. *Fittings, Reverberation of Pipe.* Greatest culprit is spring-loaded tap on end of long supply pipe. Protective provisions and penalty of value in elimn. of defective fittings. *Metered Supplies.* Sensible way of meeting increased capital expenditure for peak summer demand (at resorts) is to surcharge March–September meter charges by 1d. or 2d. per 1,000 gal.

Appendix I. Intention to collect scientific information from borings, well sinkings and other work, and make available for information of all concerned with water supply. *Appendix IIIA. Transfer and Compensation of Officers.* Provides for protection of interests of such officers and payment by local authority to officer who suffers direct pecuniary loss by reason of det. of appointment or diminution of emoluments.—*H. E. Babbitt.*

The Protection of the Public Interests in Public Contracts. HERMAN G. JAMES. Public Admin. Service, Chicago (1946). Contains a 47-p. exposition plus a 43-p. summary of national, state and local legal provisions and a draft of an act regarding public contracts. Chapters on: Characteristics of Public Contracts; Classification–Construction, Material Purchase, Services and Land; Provisions for Public Interests; Competitive Bidding; Award Exemptions; Remedies for Violation in Competitive Bidding Provisions; Control over Contract Performance; Direct Performance

vs. Contract. To supply in small measure lack of available information, study attempts to show what has been and should be done on public contracts for better protection of public. Constitutional and statutory provisions in all states have been examd. as well as charter and ordinance provisions in some prin. cities. More technical legal aspects not discussed because these vary state to state, city to city and even ordinance to ordinance. The field of public contracts steadily expanding. Public interest always demands competitive bidding and award of contract to bidder making most advantageous offer to public. Complete success cannot be hoped for because honesty of public officers and interest of public essential to realization of the desired ends. Rejection of most economically favorable should only be by extraordinary majority justifying such action in public records. Many details to be detd. by awarding authority, which naturally vary with size and character of the particular contract. Must be remembered that honest public officials likely to be irked by restrictions on freedom of action in the public interest, and dishonest ones will try to reduce such restrictions.—*O. R. Elting*

City Water Rights Upheld. ANON. Pub. Util. Fort. **32**: 648 (Nov. 11, '43). Ancient "pueblo" rights granted city of Los Angeles by King of Spain to waters of Los Angeles R. upheld (Oct. '43) by state sup. ct., which gave city full rights to waters of San Fernando Valley. Litigation between cities of Burbank and Glendale and of Los Angeles over underground waters of San Fernando V. carried on for 7 yr. Lower courts upheld city's rights to waters brought from Owens V. which reached underground basins through irrigation and spreading grounds but held that water which reached underground storage through conservation by Los Angeles Flood Control Dist. open to appropriation by anyone having access to it. Although cities of Glendale and Burbank spent 5 million and 2 million dollars, resp., in development of this source, and using water, court held that prior rights of city of Los Angeles not affected. —*H. J. Chapton.*

Montana Public Service Commission. *Town of Whitehall* v. *Meredith Edna Roe et al.* Pub. Util. Fort. (PUR) **49**: 123 (Aug. 19, '43). Complaint by municipality against water consumers beyond corp. limits for purpose of obtaining order directing municipiality to cease operation of extension. Approx. 2200′ extension constructed in '18 by sugar beet factory promoters for factory use only. 15 homes first connected to line of which only 12 now users. Pipeline constructed of inferior materials and now in need of replacement. Continuance of service means loss to municipality through leakage and fire protection upkeep. Com. states that under statute defining its powers and duties town of Whitehall cannot be compelled to furnish water to customers outside its corp. limits and com. concludes that since town desires to discontinue service no order of com. necessary.—*H. J. Chapton.*

Legislation and Court Decisions. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5**:D:10:54 (Nov. '43). Notes from decision of Court of Arbitation in case of Mayhew *v.* Trenton Pub. Util. Com. Mayhew operated grist and flour mill by water power derived from mill pond on Mayhew Creek, small watercourse with drainage area of approx. 15 sq.mi. Periodically, about 25 hp. generated. In '41, town of Trenton expropriated 1000 gpm. from stream, which for about 5 mo. of yr. represented entire flow, necessitating drawing down of mill pond periodically to obtain power for mill. Annual cost of power, capitalized at 3%, was $15,000 and Mayhew claimed addnl. $1500 for 25-hp. motor and its maint. in perpetuity. Awarded $15,000.—*R. E. Thompson.*

Wisconsin Public Service Commission. Re *Iron River Water, Light and Telephone Co.* Pub. Util. Fort. (PUR) **48**: 190 (June 24, '43). Com. began investigation of co. rules, regulations and practice after complaint by customer that utility refused to repair leak in water main serving his premises. Com. found utilities' rules and regulations adopted in 1892 and no revisions made since that time. During early growth of utility, many customers hooked on to services of neighbors who had already tapped main. About 20% of about 200 water takers get service from lines with at least 2 customers connected and in many cases utility not consulted before extensions made. Many of these mains small sized pipe ½″ to ¾″ in diam. and not satisfactory for service to several customers. They have short service life and should be replaced as soon as materials again available. Some of these pipes have length of block or more and serve several groups of customers. Due to disagreement between extension

owners as to who should make repairs, utility forced to repair said lines to prevent loss of its water. Tentative draft of proposed rules and regulations submitted to util. for comments and criticism. Set of rules then prescribed by Com. Normal procedure in Wis. is for water utils. to maint. mains and services up to curb at their expense. Certain Class A water utils., however, require property owners to maint. service lines from main to meter. Com. considers equitable rule for use at Iron Mountain is requirement that util. maint. all services from street main to and including curb cock and box and correct without expense to property owners any defective condition that may be found between main and curb. Should defect be found between curb stop nearest main to which service tapped and premises using water, property owner should be notified to have the defective condition corrected at his own expense. Following example indicates how, under prescribed rules, service line to premises may be replaced. Say main is approx. 325′ long and there are 4 customers on main using $40 worth of water per year. Under proposed rule, co. will extend and finance main costing 5 times annual income, or $200. If main costs $422.50, customers would be required to contribute $222.50 or $55.62 each. If within 5 yr. an additional customer connected and his estd. use of water $10 per year, or $50 for 5 yr., co. would refund $50 to 4 original customers, or $12.50 each. Avg. contribution would then be $43.12. New customer would be required to pay connection charge of $43.12 which would be divided equally among original 4 customers, making refund of $8.62 to each. Each connection thereafter would cost $34.50 until saturation of customers or larger use of water elimd. charge entirely. Com. found existing rules, regulations and practices of util. inadequate, obsolete and unreasonable and new prescribed rules to be reasonable.—*H. J. Chapton.*

Wisconsin Supreme Court. *City of Milwaukee* v. *Public Service Com. et al.* Pub. Util. Fort. (PUR) **52:** 123 (Mar. 30, '44). Action commenced July 8, '38, *City of Milwaukee* v. *Pub. Service Com. of Wisconsin,* town of Greenfield and city of West Allis, to set aside order of com. establishing rates and rules for extension of water service by West Allis to Lapham-Orchard San. Dist. in Greenfield, Milwaukee County, Wis. Trial ct. dismissed plaintiff's complaint and appeals. West Allis, a munic. water utility, purchases its water from Milwaukee, also a munic. water utility. Lapham-Orchard San. Dist. contiguous to West Allis but does not adjoin Milwaukee. Plaintiff claims service of water by West Allis to Lapham-Orchard San. Dist. places addnl. cost and burden upon Milwaukee utility. Fact that Milwaukee suffered due to sale of water by West Allis to Lapham-Orchard not disputed, but this fact did not make it a party in interest and entitled to maint. action to set aside order of Public Service Com. fixing rates and rules to be charged by West Allis. Ct. stated that if difference exists between Milwaukee and West Allis it must proceed before Public Service Com. or the cts., as the facts and law in case require.—*H. J. Chapton.*

Service Denial Because of Unpaid Bill Under Another Name. *Caro* v. *Northern Pennsylvania Power Co.* Pub. Util. Fort. **33:** 522 (Apr. 13, '44). Complainant, a woman, obtained elec. service at residence occupied by mother and self under mother's name. Service denied for nonpayment. Same woman again applied for service at new location in her own name but, recognized by co. employee as person responsible for unpaid bill, was refused service. In upholding this action Pennsylvania Com. stated: "It is a well-settled principle of law that when one contracts with an individual face to face and intends to contract with the person before him, the contract, if any, is made with that particular person, regardless of whether the assumed name is actually the name of a living person. . . ." No evidence of agency relationship between mother and daughter on record.—*H. J. Chapton.*

Health Department Order Sustained by Supreme Court. N.Y. Health News **22:** 77 & 79 (May 14, '45). Because no action taken to install water chlorination equip. in accordance with recommendations of State Dept. of Health, State Comr. of Health, following hearing, issued formal order to village officials that such equip. be provided. Terms of this order not complied with and matter referred to Atty Gen., who brought action in Supreme Court having jurisdiction. Decision in this case discloses that no issue of fact raised at trial. Neither authority of State Comr. of Health to act under provisions of Public Health Law, nor his exercise of administrative judgment argued, but admitted. Decision ordered officials of village to comply with

terms of order. Every effort made to secure necessary improvements to water supply system before official action taken.—*P.H.E.A.*

Referendum Not Necessary for Chlorination of Polluted Public Water Supply. N.Y. Health News. **22**: 1 (Jan. 1, '45). Order of State Comr. of Health directing village to chlorinate its pold. water supply within police power of state and held mandatory under provision of State Public Health Law. Village board has sufficient power under Village Law of state to provide funds for and authorize treatment without referendum. Although referendum held and defeated, village board must comply with order according to opinion of State Attorney General. —*P.H.E.A.*

SOFTENING AND IRON REMOVAL

A Rural Water Softening Plant. ANON. Wtr. and Wtr. Eng. **49**: 33 (Jan. '46). Work at Petches Bridge Pumping Station of Braintree Rural Dist. Council shows co-operation between authorities concerned to supply required quant. of water of desired qual. Lime-soda process selected for treatment of water from borehole which had total hardness of 360 ppm. Quant. required to be treated was 15,000 gal. (Imp.) per hour, resulting in reduction of hardness to 100 ppm.; elimination of iron; no excess alkalinity; and suitability in all respects for drinking. Lime-soda softening entailed double pumping. Chemical treatment for softening, removal of CO_2 and elimination of iron consists in dosing raw water with hydrated lime and sodium aluminate. Reaction rapid, good floc formed and sedimentation good, so that load on filters light. Mechanical mixing and flocculating equip., driven by small motor, installed in central downcomer reaction compartment. Three 8-ft. diam. pressure-type sand filters installed for final clarification of softened water. Equip. installed for applying dose of acid salt soln. to filtered water to neutralize excess alky. or stabilize final water if necessary. Sludge disposed of into lagoons formed on adjacent waste land.—*H. E. Babbitt.*

Purification of Hard Waters by Means of Technical Lignin, By-product of Wood Saccharification. HENRI GAULT & K. W. HIONG. Compte. rend. (Fr.) **220**: 608 ('45). Technical lignin, retaining about 42% cellulose (100 g.), gradually triturated with 1 kg. H_2SO_4 until temp. reached 60°C. Mixt., after standing for 1 hr. at room temp., poured into 3 l. H_2O, and residue filtered and washed with H_2O, $NaHCO_3$ (until neutral) and H_2O, and then dried at 110–20°C. Black granular mass (**I**) could be used directly or after mech. disintegration for all purposes requiring cationic exchange, and found to be especially effective in softening hard water. When through a column 4 × 5 cm. contg. 20 g. **I**, 2 l. of H_2O (originally contg. about 245 ppm. total solids) passed at rate of 50 ml./min., total solids reduced to 10–20 ppm. Regeneration of **I** possible by treating with 10% H_2SO_4, followed by washing as outlined above.—*C.A.*

Fuel Economy Discussions. I. The Future of Lime Soda Softening. W. F. GERRARD. Chem. Age (Br.), **52**: 139 ('45). Cold lime soda process for softening water gives good results when hardness due to calcium only or, in some cases, to magnesium only; method least satisfactory when water contains both calcium and magnesium, particularly when amt. of magnesium high in proportion to amt. of calcium. Tests made in which softening carried out in 2 stages. Measured vol. of water treated with satd. soln. of lime. Concn. of lime added equiv. to temporary hardness and magnesium hardness plus 100 ppm. (as calcium carbonate). Water stirred gently for 30 min. and allowed to stand 30 min. Clear water drawn off and tested for alky. to phenolphthalein and methyl orange. After filtration, sodium bicarbonate and sodium carbonate in amts. sufficient to react with excess lime and permanent hardness added to filtrate, water stirred gently for 30 min. and allowed to settle for 30 min. Time required for softening, exclusive of that required for filtration, 2 hr. Results obtained as good as those obtained with same water treated for same period using hot lime soda process in combination with treatment with sodium aluminate. Calcium carbonate pptd. during second stage did not filter well through coarse material. When in stage 2 treated water made to flow upwards through bed of crushed limestone or calcite, calcium carbonate completely removed in 10 min. Best results in removing calcium carbonate ob-

tained when water passed through paper pulp in which calcium carbonate had been entrained; when water stirred with paper pulp for 10 min. and pulp allowed to settle, filtrate contained less than 25 ppm. calcium carbonate. Use of paper pulp in stage 1 also gave good results but cotton pulp not satisfactory for removal of magnesium. Treatment in 2 stages reduced content of silica in water to less than 4 ppm. Water having temporary hardness of 275 ppm., permanent hardness of 210 ppm., calcium hardness of 345 ppm., and magnesium hardness of 140 ppm. treated in 2 stages with 381 ppm. lime, 101 ppm. sodium bicarbonate and 180 ppm. sodium bicarbonate. Paper pulp used in both stages. Total period of softening 30 min. Treated water contained 24 ppm. calcium hardness and 3 ppm. magnesium hardness. Same water treated with lime and soda simultaneously had total hardness of 200 ppm.after 30 min. and of more than 100 ppm. after 2 hr. Alky. of treated water can be regulated by varying amt. of sodium bicarbonate added.—*W.P.R.*

Solubility of Calcium Carbonate in Pure Water and in Water From Which Carbon Dioxide Has Been Removed. W. Wesly. Chem.-Ztg. (Ger.) **68**: 189 ('44). Water that has been softened by addn. of lime in amt. equiv. to carbonate hardness contains dissolved calcium carbonate or magnesium carbonate and dissolved calcium hydroxide. Author describes his detns. of soly. of calcium carbonate in pure water and in water that, contg. originally only calcium bicarbonate, has been "decarbonated" by addn. of lime followed by heating or by heating only. Pure distd. water, almost completely free from CO_2, made as follows: Condensed steam passed through base-exchange material (Wofatit) and, after addn. of caustic soda, distd. 3 times, rejecting first runnings in each case. Finally water boiled under reflux 2 hr., with stream of nitrogen free from CO_2 passing through it. To det. soly. of pure calcium carbonate in purified water, 1 g. shaken with 1 l. for 6 hr. at room temp. Liquid filtered through glass filter crucible into vessel filled with nitrogen, and titrated to phenolphthalein and methyl orange end-points. Tests showed that calcium carbonate used contained no significant amt. of calcium hydroxide. Titration results gave soly. of calcium carbonate as 13 mg./l. at room temp. To det. soly. of calcium carbonate in water in which calcium bicarbonate has been converted to carbonate by addn. of lime and heating or by heating only, following methods used. In those expts. in which lime used, soln. of calcium bicarbonate (prepd. by passing CO_2 through suspension of calcium carbonate in distd. water) treated with quant. of cp., solid lime equiv. to carbonate hardness and excess free carbonic acid, and, after heating for 1 hr. at 95°C. under reflux, quickly filtered in nitrogen through sintered glass crucible and titrated hot to phenolphthalein and methyl orange end-points. In some expts. in which heating only used, soln. boiled under reflux for 1 hr. and in others for 8 hr.; soln. then filtered and titrated as before. Whichever method used, avg. value found for soly. of calcium carbonate was 24 mg./l. at 95°C.—*W.P.R.*

Reasons for the Addition of Lime to Drinking Water. E. D. Ducau. Bol. Obras Sanit. Nacion (Arg.) **15**: 88: 276 ('44). Use of lime in chem. treatment of water discussed. Lime added to water supply to soften water, to improve conditions for coagulation and to reduce excessive acidity which may cause corrosion in pipes and storage tanks. Water works of Buenos Aires, Arg., takes raw water from R. Plata and supplies treated water at rate of 1 mil. cu. m./day. After coagulation, addn. of 20 ppm. lime necessary to raise pH value of water which, being soft and having low pH value, would otherwise attack lead pipes carrying domestic water supply with consequent risk of lead poisoning. In addn. to reducing acidity of water, lime reacts with dissolved CO_2 to form deposit of calcium carbonate which acts as thin protective film and prevents further attack on metal by water. Water supply of Buenos Aires contains less than 70 ppm. calcium hardness and does not require softening. If desirable to soften water for indus. purposes, sodium carbonate may be added with lime, but this treatment should not be employed for water contg. less than 30 ppm. hardness.—*W.P.R.*

The Behavior and Treatment of Iron-Bearing Waters. J. H. T. Griffiths. J. Inst. San. Engrs. (Br.) **44**: 7 ('45). Important to differentiate between waters which naturally contain iron and those which have picked up iron from pipes and linings of boreholes. Waters contg. iron vary considerably in compn. Iron usually found as ferrous bicarbonate, which contact with oxygen con-

verts into ferric hydroxide. Objectionable effects of iron and manganese in water described. Removal of iron from potable water supply usually desirable if raw water contains more than 0.3 to 0.4 ppm. iron. Methods described for removing iron include internal or external aeration followed by filtration, external aeration followed by sedimentation and filtration, softening with lime or lime-soda, treatment with ion-exchange materials and oxidation of iron by chlorine. Treatment of water with sodium hexametaphosphate may prevent pptn. of iron from water. Manganese likely to be objectionable in water supplies when present in concns. greater than 0.2 to 0.4 ppm. Methods adopted for removing iron often reduce content of manganese to negligible amts. although sometimes removal of manganese very difficult. May be necessary to increase pH value of water to appreciably higher figure than would be necessary for removal of iron alone. Methods used for removing manganese include ion exchange and treatment with potassium permanganate, with sodium hydroxide, sodium aluminate and potassium permanganate, or with ferric sulfate and lime. Many waters contg. iron also contain iron bacteria, most common of which are *Leptothrix* and *Crenothrix*. Characteristics and control of iron bacteria described. Odors in water contg. iron usually due to hydrogen sulfide, produced by action of sulfur bacteria on sulfates or to decaying iron bacteria. All waters contg. iron contain also free carbon dioxide; methods for removing carbon dioxide from water described. Soft waters contg. iron usually colored moorland waters; when treating such waters necessary both to remove iron and increase pH value to render water non-corrosive. Water obtained from borehole or well which is worked intermittently may contain more iron and carbon dioxide than supply obtained continuously from underground sources. Economical method of treating such small supplies is to spray 2 or 3 days' supply of water into sedimentation tank. After settlement water treated with alk. to increase pH value and passed through filter to remove iron from water before it reaches storage tank.—*W.P.R.*

Experiences in the Use of Cooling Water Treated With Sodium Hexametaphosphate. Koestle. Wärme (Ger.) **65**: 292 ('42); Chem. Zentr. (Ger.) **2**: 2187 ('42). When lime used to soften makeup water for cooling system, deposits of scale may form on heated surfaces in system. When water with carbonate hardness of 14.56° (Ger.) treated with 2.6 g./cu.m. of sodium hexametaphosphate, found that scale non-adherent and formed only on those parts of equip. where temp. above 80°C.—*W.P.R.*

Use of Sodium Hexametaphosphate in the Treatment of Water (Containing Dissolved Iron) from a Borehole at Scalby, York. H. Ingleson. Wtr. and Wtr. Eng. (Br.) **49**: 14 (Jan. '46). Investigation extending over several months made to ascertain whether regulated addn. of small amts. sodium hexametaphosphate to hard water from borehole at Scalby, Yorkshire, prevents pptn. of iron already in soln. in water. Found that when concn. of hexametaphosphate maintd. at 2 ppm., amt. of iron pptd. in interval between pumping of water and delivery to consumer negligible. Some complaints that baths and sinks stained when taps allowed to drip. With increased dose to 3 ppm. occasional complaints of discoloration of water from outlying parts of dist. With doses of 2, 3, or 4 ppm., part at least of iron in soln. pptd. on boiling, and colors scale formed in kettles and domestic boilers reddish-brown. On whole, addn. of hexametaphosphate may be said to have alleviated difficulty caused by iron in soln., though not to have removed it entirely. —*H. E. Babbitt.*

Removal of Manganese From Water. J. P. Lawlor. Chem. Abstracts. **39**: 143 ('45). In prepn. of bed of material which can be used to remove manganese from water, suspension of finely divided particles of manganese compd. in water first passed through layer of sand in order to coat grains with manganese dioxide. This layer subsequently added to larger layer of sand in which grains free from any deposits of manganese; coated and uncoated grains then in contact. When water contg. finely divided particles of manganese compd. in suspension passed through both layers, deposit of manganese formed on uncoated grains of sand and eff. of bed in removing manganese from water increased. Description of app. used given.—*W.P.R.*

Removal of Silica From Water by Calcined Magnesia. Chem. Zentr. (Ger.) **1**: 195 ('43). Calcined magnesia used for removal of silica from water regenerated with dil. solns. of mineral acids or org. acids which are made to flow upwards through granular magnesia. Magnesia activated with water

contg. CO_2. After regeneration magnesia treated with soln. of ferric or aluminum or other salts which have an acid reaction, with soln. of ammonia or with warm soln. of coagulant such as magnesia which contains little or no silica. Many other methods of carrying out process described.—*W.P.R.*

Determination of Calcium Content and Total Hardness of Water. Abraham Saifer & Franklin D. Clark. Ind. Eng. Chem.—Anal. Ed., **17**: 757 ('45). Forty-five ml. of sample neutralized with concd. NH_4OH and 1 ml. in excess added. After diln. to 50 ml., soln. filtered if necessary. A 2-ml. aliquot dild. to 5 ml., and 5-ml. aliquot treated with 5 ml. of K oleate-Duponol reagent in colorimeter tubes. After 30 min. percentage transmission measured against blank contg. 0.05 ml. of concd. NH_4OH dild. to 5 ml. and 5 ml. of reagent. Corning No. 511 filter used. Reagent prepd. by adding 20 ml. of K oleate soln. (7.05 g. oleic acid, 1.60 g. KOH, 5 ml. H_2O, and 50 ml. 70% EtOH refluxed for 1 hr. and dild. to 250 ml.) to 100 ml. of 3% Duponol soln. Reagent stable at room temp. Ca contents from 8 to 350 ppm. detd. to within 4% in higher concns. Mg detd. photometrically by method of Ludwig and Johnson (*C.A.*, **37**: 578) with 0.05% soln. of Titan Yellow in 2% Duponol. Total hardness calcd. from Ca and Mg contents.—*C.A.*

WATER WORKS ANNUAL REPORTS

Fort Smith (Ark.) Water Dept. Annual Report (1944). Estd. pop. 49,300; consumption 52. 1mgd. Supply 74 sq.mi. watershed; 3500-mil.gal. reservoir with 23-mi. pipeline to 9-mgd. filtration plant. Distr. system of 350 mi. of main and 17 mil.gal. storage. Treated water: total hardness 46.3 ppm.; pH 8.7. Plant $4,154,000; securities $320,000; bonded debt $1,332,074. Income $331,673; operating expense $116,969; interest $43,340; bonds $12,000; surplus $159,364.—*O. R. Elting.*

Long Beach (Calif.) Water Dept. Annual Report (For Year Ending June 30, 1945). Five-man board appointed—one each year—by city manager and approved by city council. Estd. pop. 280,000. Water consumption 23.10 mgd.; 82.5 gpd. per capita. Distr. system 394 mi., 3581 hydrants, 45,758 services, 100% metered. Well supply $\frac{5}{6}$, Colorado River $\frac{1}{6}$; elec. pumps deliver water to system and 40 mil.gal. storage in 12 steel tanks. Gross income $1,402,535, increase of $91,687 over previous year. Net after deducting depn. $499,839. Operating expenses $540,651; depn. $193,574; interest $76,458; general and admin. $92,012; bonds retired $105,000; surplus $394,840. Bonds outstanding $1,615,000; depn. value of plant $9,363,421; cash reserve fund $550,267; stores $329,871. Capital expenditure completed $297,392.—*O. R. Elting.*

Pasadena (Calif.) Water Dept. Annual Report (For Year Ending June 30, 1945). The dept. organized in '12 by purchase of 3 water cos., 33 other systems acquired. Estd. pop. 112,000; water consumption 14.8 mgd. or 132.3 gpd. per capita. War Production Board restrictions on materials and shortage of labor reduced new constr. to $62,605. Distr. system 370 mi. of 2″–36″ mains, 1776 hydrants and 30,483 services. 43% of water obtained from wells, 32% by gravity and 25% from Colorado R. by purchase from Metropolitan Water District. In Nov. '42 electors approved charter amendment appropriating for general city purposes 6% of income from sale of water. Gross revenue $1,147,029, gain of $25,037 over previous year. Operating and maint. expenses $825,330; increase of $49,466 due principally to purchase of Colorado R. water for first time. Fixed assets $7,818,006; depn. reserve $3,171,419. Total liabilities $144,682. Surplús $7,027,197.—*O. R. Elting.*

Annual Report (For Year Ending Dec. 31, 1945), Denver (Colo.). Board of Water Comrs. Pop. 414,000. Water consumption avgd. 71.04 mgd. or 172 gpd. per capita. Decrease from '44 due to heavy summer rainfall. Inability to obtain either labor or material to increase capac. of plant made it necessary to prohibit new services outside of city. Cost of shifting 90 fire hydrants to provide better coverage borne by Water and Fire Dept. in 15:4 ratio, with paving cost borne by others. Income $3,458,038; disbursement: operation and maint. $1,020,092 (30.0%); depn. $620,705 (18.2%); capital expense $1,466,700 (43.1%); invested capital $297,590 (8.7%). First cost of plant

$43,942,810; investment $3,400,000. Capital liabilities $21,322,000. Cost per mil.gal. delivered (including 4% interest on investment) $127.10. Total services 83,408; active meters 3,574; revenue 28.9% of total; 1632 services added. System consists of 115 mi. of 12″–84″ conduits and 841 mi. of 1′–48″ mains in the distr. system. 4,576 fire hydrants. Source of supply for city consumption South Platte R. 56%, Fraser R. 26%, storage 8%, Cherry and Bear Creeks 10%. Employees have mutual benefit assn. and credit union. Board has retirement plan, also promotes group insurance and hospitalization. Hillside seepage from Ralston Creek Reservoir stopped by pressure grouting of 14′ drill holes, from various canals and tunnels by program of concrete lining. Capac. filter plants and pumping stations 176 mgd. Capac. of reservoirs: distr. 99 mil.gal., operating 10,686 mil.gal., storage 63,397 mil.gal.—*O. R. Elting.*

15th Annual Report (For Year Ending Dec. 31, 1944), Water Bureau, Metropolitan Dist., Hartford (Conn.). Organized '29. Dist. includes Hartford, Bloomfield, Newington, Weatherfield, Windsor, E. Hartford and Rocky Hill. Estd. population served 327,000; consumption, max. 7-day, 34.69 mgd.; max. month 32.01 mgd.; yearly avg. 30.58 mgd. Gravity supply. Cost, operation and maint. $75.23 per mil.gal., fixed charges $77.59 per mil.gal., total $153.82 per mil.gal. Distr. system 604 mi., 38,884 services (100% metered) and 3956 hydrants. Gross revenue $1,696,075, increase of 3.8% over '43. Operating expense $861,608, increase of $47,215 over '43 despite pension insurance item of $58,393. Fixed capital $30,077,284; bonded debt $10,564,000; net worth $13,012,721. Max. hourly rate 50 mgd. Consumption in excess of 28 mgd. occurred on 238 days as against 199 days in '43. Initial direct delivery of water—Barkhamstead Reservoir to filters on Dec. 22, '44.—*O. R. Elting.*

Annual Report Water Dept., Oak Park (Ill.) 1945. Water purchased from Chicago delivered to the village through 5 meters (12″). Three other connections assure protection of supply. Pump station houses 8 motor-driven pumps combined capac. of 24 mgd. boosting pressures an avg. of 25 psi. Storage reservoir 5 mil.gal. Unaccounted flow of 14.6% due principally to curtailment of critical materials and manpower shortage has prevented the close follow-up on leaking services and meters. Estd. pop. 69,000; consumption 5.54 mgd. or 8.06 gpd. per capita. 107.4 mi. of mains supply 12,021 meters and 1135 hydrants. System 100% metered, water sold 84.8% of total. Total income $406,033. Expenses: purchase of water $150,614; operation and maint. $87,696; interest $2,030; depn. $36,554; transferred to fire funds $135,000; net loss $5,861. Fixed assets: original $1,264,780; less depn. $249,835. Liabilities: bonds and deposit funds $64,449. Net worth (assets over liabilities) $476,367. Immediate $400,000 improvement of distr. system planned.—*O. R. Elting.*

Des Moines (Iowa) Water Works Report (1945). Operates under 5-man Board of Trustees. Population 182,127, consumption 17.18 mgd. or 94.3 gal. per capita. Water under pressure of 38–118 psi. delivered through 431 mi. of 4″ to 36″ mains to 3685 hydrants and to 40,063 services, 99.5% metered. Account for 85.3% of water pumped. Gross income $1,025,181; operation and maint. $402,086; net income $623,095; depn. $129,251; interest and sinking fund $295,933; surplus $197,911. Plant less depn. $7,474,711; total assets $8,755,049. City's equity $4,812,069. Pumping: max. 30.3 mgd.; min. 6.6 mgd.; avg. head 275.3 ft. Coal 15.2% ash; 9,070 Btu. as fired. Evapn. ratio 5.71; coal per 1000 gal. pumped, 3.57 lb.; boiler and stoker eff. 68.3%; station steam duty 112.4; overall thermal eff. 9.10%. Total hardness: max. 420, min. 290, avg. 366 ppm.; pH 7.35. Rainfall 37.36″, 5.32″ above normal; air temp. avg. 50°F., max. 88°F., min. 0°F.; water temp. avg. 54°F., max. 67°F., min. 42°F.—*O. R. Elting.*

88th Annual Report (For Year Ending Dec. 31, 1945), Louisville (Ky.) Water Co. For 6th consecutive year, earnings exceeded all previous records. Revenue $2,682,802; $44,857 increase over '44. Net profit $1,429,710; $61,769 increase over '44. Sinking Fund Board paid $1,300,000. Bonded indebtedness of $1,000,000 offset by $919,831 reserve fund. Cash fund of $900,243 reserved for expansion and improvements. Fixed capital $23,014,597; co. equity $11,723,873. Estd. pop. 375,000. System owned by city and operated by board. Original constr. in '50. Ohio R. water pumped to reservoir and re-pumped to system. Consumption 57.10 mgd., a decrease of 0.91 mgd. from '44. 152 gpd. per capita, 741 gpd. per service. Rebate

of 50% made to 1145 victory gardeners. Active services 77,052, 100% metered, a 694 increase over '44. System has 746 mi. of main, 4.4 mi. added during '45. Cost of pumping of Riverside Station (elec. pumping with steam standby) $4.085 per mil.gal. raised 100′ compared with $3.248 for '44. Crescent Hill Station $5.441 per mil.gal. 100′ high compared to $5.347 for '44. Cost of purif. $5.805 per mil.gal. divided: superintendence $0.622; operating labor $1.275; chems. $2.669; wash water $0.385; heat, light and power $0.184; supplies $0.143; maint. $0.527. Filter runs: East 53.61 hr., South 55.48 hr., North 50.50 hr. Wash water 1.90% of total filtered. Avg. chemical dosage in ppm. filtered: alum, 16.1; pebble lime, 7; in lb. per mil.gal.filtered: Cl. 17.60; ammonium sulfate 5.61; activated carbon (intermittent use only) 27.84. Detns. for (1) 37° count, (2) coliform organisms per 100 ml. (3) turbidity, and (4) alky. avgd.—river water: (1) 6064, (2) 3013, (3) 149, (4) 52; settled water: (1) 3179, (2) 84, (3) 95, (4) 50; coagulated water: (1) 1851, (2) 85, (3) 26, (4) 43; filtered water (1) 2.97, (2) 0, (3) 0, (4) 52. Filtered water: total hardness 115 ppm., pH 8.0, total solids 218 ppm., chloride 22.6. Contracts entered into for investigation of ground water supply east of River Pumping Station. Contracts entered into for construction of rapid mixing, basins, flocculators, clarifier and decarbonization basin to increase capac. of coagulation treatment of settled water. Completion, set for May '46, will permit handling of most turbid water at 80 mgd. and hardness reduced to 80 ppm. Contract entered into for 2-mi. 60″ concrete main between River Pump Station and Crescent Hill Reservoir. $900,000 available for future constr.—*O. R. Elting.*

93rd Annual Report (For Year Ending June 30, 1945), Dept. of Water Supply, Detroit (Mich.). Dept. operates under 4-man Board of Water Comrs. Estd. pop. served, 2,322,417; 437,390 services; 99% metered. 28,448 hydrants in city of Detroit only. Water supply Detroit R. distributed by direct pressure (except for 6 elevated tanks with total capac. of 9.5 mil.gal.) through 5192 miles of mains by two pumping stations with total installed pumping capac. of 1068 mgd. Two rapid sand filter plants with total rated capacity of 592 mgd. Revenue from sale of water $9,637,899, or $4.19 per capita, $29.31 per account, $1,904 per mi. of main, $80.85 per mil.gal. Operating and maint. expense of $3,951,101 or $33.14 per mil.gal. divided: general plant $0.51; water collection and low-lift pumping $2.27; purif. $3.62; high-lift pumping $7.92; distr. $6.93; repairs and replacements 0; commercial $4.43; general expense $7.45. Capital expense $4,399,306: interest $2,499,076; bonds retired $1,157,000; and sinking fund payments $743,230. Net cost of works $128,834,890; bonded debt $59,901,792; value of sinking fund $18,536,792; avg. interest rate 4.11%. Income and expenses per 1,000 cu.ft. (revenue water basis): revenue $0.712; operation and maint. $0.292; fixed charges $0.330; net income $0.090. Daily pumpage avg. 326.58 mgd. Max. 510.48 mgd.; min. 229.80 mgd. Avg. consumption 141 gpd. per capita or 745 gpd. per service. Operation of the two plants was as follows:

	Water Works Park Plant	Springwell Plant
Purification—avgs.		
Rating, *mgd.*	320	272
Water filtered, *mgd.*	170	165
Filter run, *hr.*	41	40
Wash water, %	2.7	4.3
Rate of filtration, *mgd./acre*	153	137
Chem. Dosage—lb./mil.gal.		
Alum	66.5	72.2
Ammonia	0.83	0.84
Pre-chlorine	3.13	3.34
Post-chlorine	1.79	2.04
Effluent—avgs.		
Turbidity, *ppm.*	0.2	0.1
Residual Cl, *ppm.*	0.27	0.27
Free CO_2, *ppm.*	4.0	5.8
pH	7.6	7.4
Total alky., *ppm.*	78	79
Pumping		
Rating, *mgd.*	500	568
Avg. pumpage, *mgd.*	165.3	161.2
Coal, *Btu./lb.*	13,324	13,670
Ash, %	9.54	9.60
Coal required to raise 1 mil.gal. 100′, *lb.*	751	463

2247 new services installed, 179 removed. Nine maint. crews of 4 men each employed repairing 550 broken mains; 174 leaking joints; 982 service leaks; one crew employed repairing broken and leaking gates and cutting

out obsolete gates. Hydrant div. inspected 11,034 hydrants, repaired 600 leaks, set 211 new hydrants, repaired 102 defective hydrants, thawed 432. Garage maint. force of 6 men cared for 150 cars and trucks, 2 air compressors, 2 tractors and 38 trailers; servicing done by night emergency crew. Mains laid 7679′, discontinued 4222′ in Detroit. Avg. no. salaried employees 472; per diem employees 445. Cost of operation and maint. of 20-story Water Board Building 92.0¢ per sq.ft. of rentable area. Water Board occupies 7 floors, remainder occupied by various city departments. Sewage disposal system operated under board's jurisdiction. Advance planning occupied large portion of eng. time. Postwar projects total $20,000,000.—*O. R. Elting.*

52nd Annual Report (For Year Ending Sept. 30, 1945), Munic. Service Com., Wyandotte (Mich.). Pop. 32,000. Comrs. appointed by mayor and confirmed by council, comprise 5-man board operating elec. and water utilities. Elec. Div. net income $294,346 after deducting all charges including depn. Dividend 15% of annual bill paid customers. Elec. plant, debt free, depn. value $1,712,075; extension fund $725,143. Customer cost: residence 2.6¢, commercial 2.9¢, power 1.8¢ per kwhr.—subject to 10% dividend. Plant capac. 21,600 kva., power generated 34,527,800 kwhr., 9342 customers. Water Div. net income $43,454 after deducting all charges including depn. Depreciated plant $1,296,467; investments $212,716. Debt $473,919; income $186,287. Expense percentage: pumping 10.2, purif. 15.1, distr. 20.5, office and admin. 6.3, interest 12.5, other expense 11.6, surplus 23.3. Depreciated fixed capital: $40.51 per capita or $167.48 per customer, operating revenue $22.98 per customer. Consumption: 3.55 mgd. or 110.7 gpd. per capita; max. rate 6 mgd. Plant: six 1-mgd. rapid sand filters, 1.4 mil.gal. underground and 0.5 mil.gal. elevated storage. Pump capac. 14.8 mgd. Distr. system 92.7 mi. of mains, 750 hydrants, 7741 services. City plans tunnel to Canadian waters for better raw water supply.—*O. R. Elting.*

Purification of Cleveland (Ohio) Water Supply, Report for 1945. Supply: Lake Erie. Two purif. plants: Division Ave. and Baldwin. 80,930 mil.gal. delivered to plants, 94.2% delivered for consumption. Div. Ave. 42.9%, Baldwin 57.1% of total. Coliform indices of finished water from both plants zero. Typhoid incidence and death rates 6.0 and 0.0 per 100,000. First year of zero death rate. Discontinuing use of ammonia reduced number of soil form or late gas-forming type. Chloramine residuals made possible due to ammonia nitrogen in water, probably from sewage or trade wastes in raw water. When better means of controlling free residual chlorination available, will probably be possible to induce chlorine residuals at all times instead of chloramine residuals part of time, whether or not ammonia is present. Weekly tests in distr. system indicates little change in bacterial quality and other characteristics from tests at plants. The pH increased. Chlorine residual of 0.50 ppm. goal for finished water. Open reservoir will be covered to remove aerial pollution. Red water complaints reduced due to increase of true chlorine residuals carried further into distr. system. Tastes and odors caused by phenolic bodies or algae sufficiently intense to demand carbon treatment. Plants not properly equipped for carbon use.

	Division Ave. Plant	Baldwin Plant
Water Delivered to Plant, *mil.gal.*	34,898	46,032
Daily Avg., *mgd.*	95.6	126.1
Max., *mgd.*	132.8	157.0
Min., *mgd.*	70.2	105.8
Wash Water, %	3.24	3.43
Filter Period, *avg. hr.*	21	26
Alum Used, *ppm.*	15.24	19.04
Lake Water Turbidity, Avg., *ppm.*	12	9
Max., *ppm.*	80	57
Min., *ppm.*	1	0.5
Chlorine Used, Pretreatment, *ppm.*	1.09	1.04
Sterilization, *ppm.*	0.61	0.61
Total Alky., Lake Water, *ppm.*	94	90
Filtered, *ppm.*	84	83
Filtered Water Avg., *ppm.*		
Calcium	33.6	32.9
Magnesium	8.6	7.2
Iron	0.04	0.03
Sulfate (SO_4)	18.0	18.0
SiO_2	1.5	0.5
Total Solids, *ppm.*	159.0	162
pH, Lake	8.2	8.0
Filtered	7.4	7.4
Carbon Dioxide, Filtered, *ppm.*	2.9	3.0

	Division Ave. Plant	Baldwin Plant
Coliform Organisms/ 100 ml.		
Lake	272	75.8
Filtered	0	0
Cost, *$/mil.gal.*		
Operation	5.200	4.385
Plant Maint.	0.815	0.576
General Maint.	0.488	0.617
Total Purif.	6.503	5.578
Pumping	1.417	1.480
Capital	0.060	0.015
Avg. Water Temp., *°F.*	50.7	52.3

—*O. R. Elting*

Annual Report (For Year Ending Dec. 31, 1945), Water Dept., Seattle (Wash.). Estd. pop. served 533,931. Estd. consumption 74.60 mgd. or 157 gpd. per capita. Peak 161.2 mgd. Water mains total 1153 mi. serving 103,170 services (100% metered) and 10,399 hydrants. In '45, 19.7 mi. of mains, 97 hydrants, 2444 services added. Gross operating revenue $4,304,590; non-operating revenue $60,156; operating expense $651,862; depn. $646,666; interest on bonds $157,282; amortization of franchise and bond discounts $600; taxes $1,044,182 leaving net income $864,144 added to surplus account total $14,278,540. Anticipated drop in revenue at war's end did not take place; net profits exceeded all previous years. Depreciated net value of resources $23,264,184. Outstanding bonds $3,468,000. Tap water: total hardness 26.0 ppm.; pH 7.2; Cl 1.9 ppm. Cost of water delivered per mil.gal., operation, maint. and depn. $46.50; total $91.70. Manpower shortage eased up at end of year, raised avg. employees to 207.9 as against 190.9 in '44. Sick leave avgd. 2.2%. Sanitary branch organized during year showed excellent results in compliance with new standards and regulations of U. S. Public Health Service. Steps taken to acquire site for extension to south shops and for reservoir and elevated tank in West Seattle.—*O. R. Elting.*

Green Bay (Wis.) Water Dept. Report (1945). Five-man Board of Comrs. Consumption 4.14 mgd., 11,046 metered services, 753 hydrants. Income $271,328; operating expense $116,121; depn. $30,541; interest $39,950; taxes $38,412; surplus $46,304. Assets: plant $2,158,294; cash $108,182; other $83,215; total $2,349,691. Liabilities: debt $645,000; constr. contribution $509,894; city equity $125,000; depn. $494,990; surplus $564,468; other $10,339.—*O. R. Elting.*

Tenth Biennial Report (1943–44) Board of Water Supply, City and County of Honolulu, T.H. Present drought, longest on record, and 52% increase in pop. in past 4 yr. have resulted in heavy draft on artesian supply, decreasing artesian pressures below previous low in '26. Definite indication of salt water encroachment. Water requirements of city have increased from 35 mgd. in '38 to 69 mgd. in '44. New underground development (North Halawa) completed in Dec. '44 at cost of about $2,000,000, will provide 20 mgd. Project consists of 919′ horizontal water development tunnel 6.5′ × 10′; underground pumping station; and 4.2 mi. of 42″ and 36″ connecting main. Tunnel is in lava and yields about 80 gpd. per sq.ft. of exposed area per ft. of drawdown. Chloride content drops from 50 ppm. at low pumping rate to 32 ppm. at 7.5-mgd. rate. Ground water statute proposed to make all ground water in Oahu public property. Recharging tunnels in lava will be constructed to increase artesian supply. Appropriation requested to acquire private lands within forest reserve area to protect ground water supply. Number of leaking artesian wells sealed or recased. Leakage from one well estd. at 0.5 mgd. On order of Military Governor, chlorination of city water supply begun in Jan. '43. Manganese content of one source of supply created high chlorine-demand rate, resulting in pptn. of hydrated manganic oxide as a brownish-black sludge. This condition controlled by keeping chlorine application rate as low as practicable. Study of salt water encroachment made by collecting 250 samples of water from wells each month. Large valve-closing machine in use which requires less than 2 min. to close 36″ gate valve that normally would take 3 men ½ hr. to close. Air power unit for cutting c-i. pipe built which reduces the time required by 4 men to handcut 24″ pipe from more than 1 hr. to about ½ hr. Data given on water anals., dischg. of tunnels, streams and springs, static head, chloride content, draft from artesian wells, and rainfall.—*R. M. Leggette.*